UNCLASSIFIED

AD NUMBER
AD813077
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited. Document partially illegible.**
FROM: **Distribution authorized to U.S. Gov't. agencies and their contractors; Critical Technology; 15 FEB 1967. Other requests shall be referred to Air Force Technical Applications Center, Washington, DC 20333. Document partially illegible. This document contains export-controlled technical data.**
AUTHORITY
USAF ltr dtd 25 Jan 1972

THIS PAGE IS UNCLASSIFIED

AD813077

STATEMENT #2 UNCLASSIFIED

This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of AFTAC Wash D.C.
Attn: Vela Seismological Center

SCIENCE SERVICES DIVISION

TEXAS INSTRUMENTS
INCORPORATED

VT/6704

15 February 1967

CUMBERLAND PLATEAU OBSERVATORY

Quarterly Report No. 6

1 November 1966 through 31 January 1967

James P. Edwards III, Program Manager
FL 7-5411, Ext. 725

Stephen A. Benno, Deputy
Dale P. Glover, Deputy

TEXAS INSTRUMENTS INCORPORATED
Science Services Division
P. O. Box 5621
Dallas, Texas 75222

Contract AF 33(657)-14648
Beginning 1 May 1965
Terminating 30 April 1967

Prepared for

AIR FORCE TECHNICAL APPLICATIONS CENTER
Washington, D.C. 20333

Sponsored by

ADVANCED RESEARCH PROJECTS AGENCY
Nuclear Test Detection Office
ARPA Order 624
Project Code 5810

TABLE OF CONTENTS

LIST OF APPENDIXES

LIST OF TABLES

LIST OF ILLUSTRATIONS

SECTION I

INTRODUCTION

Work conducted by Texas Instruments Incorporated from November 1966 through January 1967 under the Cumberland Plateau Observatory (CPO) contract is reviewed in this quarterly report. Efforts during this quarter have been directed toward observatory operations, hardware construction and on-line implementation, and Dallas-based supporting research.

Observatory operations and additional data on the "coefficient loss problem" which previously existed in the MCF processor are summarized in Section II. In addition to the rapid-stop monitor for detecting marginal input power, modifications to the processor grounding system were necessary to eliminate entirely the problem of coefficient losses.

Research activities, including ambient noise studies, visual data display improvement and MCF processor evaluation, are reviewed in Section III. Data are presented which demonstrate the continued time-stationarity of the ambient noise field over a 2-yr period, thus indicating that, in at least general terms, MCF operators developed under previous efforts are appropriate for present application in the MCF processor.

Design, construction and installation of the auxiliary detection and identification processor were completed on 30 December. A description of the system and a discussion of the on-line implementation and operating parameters are presented in Section IV. Also included is a discussion of the evaluation procedures and goals and an outline of the supporting Dallas-based research.

SECTION II

OBSERVATORY OPERATIONS AND RESEARCH

This section presents results of the CPO station operations during the past quarter. Included are an analysis of the number of events reported by station personnel and a list of the station downtimes and maintenance performed. Recent advances in analyzing and correcting the MCF "coefficient loss problem" are included.

A. STATION ANALYSIS

Station analysis has proceeded on schedule during the past quarter. Data recordings have been good; the only major data loss resulted from the failure of the Beckman regulator discussed in subsection IIB-1.

The number of events reported during the quarter are as follows:

Month	Teleseisms	Regionals	Near-Regionals
November	565	9	8
December	567	—	2
January	619	4	2

The overall objective of CPO research is to enhance event detection capability. Of importance to this objective is the monthly average number of events detected during the reported quarter, which is comparable to the number reported during the previous two quarters even though the MCF processor was not operating from October through December 1966. A discussion of this point is included in Section III under the MCF evaluation.

Of particular interest in the station analysis during this quarter was the earthquake originating east of the Dominican Republic on 3 November. This earthquake generated the only T-phase reported by station personnel at CPO during the past 22 months. Table II-1 presents the various phases from this earthquake reported by station analysts.

B. STATION INSTRUMENTATION

During the past quarter, the station engineering section continued routine preventive maintenance procedures. Problems with the Beckman regulator have limited data recording (subsection IIB-1). Routine quality control shows tape and film data to contain few problems except during periods of unregulated power.

1. Major Accomplishments and Problems

As mentioned previously, the major problem encountered during this quarter was the Beckman power regulator failure for 11 days. This malfunction has limited station recordings since without the regulator both tape records and PTA's operate on unregulated power. This state, while not preventing the recording of data on magnetic tapes, left this data in an almost unusable condition.

The major engineering accomplishment during the quarter has been preparing and installing the digital and auxiliary processors. A discussion of the events and dates relating to the installation of the processor is presented in Section IV. With the installation of the processors, it was necessary to place four Develocorders on-line at the station and to reformat the trace assignments. The new trace assignments, effective 5 January 1967, are shown in Table II-2.

Table II-1

PHASES RECORDED AT CPO FROM EARTHQUAKE ORIGINATING EAST OF THE DOMINICAN REPUBLIC, 3 NOVEMBER 1966

Phase	Recording Instrument	Time	Remarks
iP	JMZ	16:29:31.8	
eP	GLZ	16:29:33.0	
e*	GLZ	16:30:38.0	
e	JMZ	16:33:25.6	Possibly PcP
eS	JMN	16:33:35.4	
eS	GLN	16:33:36.0	
eS	GLE	16:33:36.0	
eL	GLN	16:34:44.0	
eL	GLE	16:34:44.0	
eR	GLZ	16:35:06.0	
eR	GLN	16:35:06.0	
eR	GLE	16:35:06.0	
e	JME	16:40:42.8	Possibly ScS
eT	JMN	16:47:06.5	T Waves - Indefinite start—Continue for approximately 9 min

*e indicates a phase was recorded but not identified

Table II-2

DATA FORMAT ASSIGNMENTS

CHANNEL NUMBER	DEVELOCORDERS				MAGNETIC-TAPE RECORDERS	
	Data Group 6000	Data Group 6036	Data Group 6025	Data Group 6035	Data Group 6017	Data Group 6034
	No. 1 & 2 SP Primary	No. 1 & 2 SP Secondary	No. 3 LP Primary	No. 4 MCF	No. 1	No. 2
1	V	V	WI	MCF 1 MCF 3-BP	TCDMG	TCDMG
2	Z7	ΣI	MS	MCF 2 IP 10-BP	Z1	LPZ
3	Z1	ΣK	ZLL	MCF 3 MCF 3	Z2	LPN
4	Z4	ΣL	NLL	MCF 4 MCF 24	Z3	LPE
5	Z2	ΣT	ELL	BSO Σ 19	Z4	UKO Russia
6	Z3	ΣTF	ZLF	BS 1 Σ 19 N	Z5	UK 1 NTS
7	Z5	ΣG	NLP	BS 2 Σ 19 E	Comp.	Comp.
8	Z6	ΣH	ELP	BS 3 Σ 19 S	Z6	Fisher
9	Z9	Z10	ML	BS 4 Σ 19 W	Z7	Z8L
10	ΣL	Z8L	Z8	ΣT	Z8	MCF 1 MCF 3-BP
11	ΣTF	Z8	WWV	MCFP 1	Z9	MCF 2 IP 10-BP
12	ΣT	NSP		MCFP 2	Z10	MCF 3 MCF 3
13	Z8L	ESP		MCFP 3	ΣTF	MCF 4 MCF 24
14	NSPL	UKO Russia		MCFP 4	WWV & Voice	WWV & Voice
15	ESPL	UK 1 NTS		Fisher		
16	WWV	WWV		Fisher Threshold		
17				MCFP 1 Threshold		
18				MCFP 2 Threshold		
19				MCFP 3 Threshold		
20				MCFP 4 Threshold		

Table II-3 chronologically lists the engineering accomplishments and difficulties for the quarter.

Table II-3

ENGINEERING ACCOMPLISHMENTS AND DIFFICULTIES

Date		Accomplishments and Difficulties
November	3	Repaired Develocorder date-timer
	3-17	Performed PTA linearity checks; worked on frequency responses and dc pulses
	14	Cable maintenance performed and new cable laid to Z9, Z14, and Z16
	16	Corrected short in cable in SPN vault
	21	Tape recorder no. 1 stopped and repaired; pressure roller assembly spring, heads and rollers gummed up
	22	Rack mounted scope checked and adjusted
	23	DC pulses and equalizations performed on all seismometers
	28	Changed malfunctioning date-timer in Develocorder no. 1
December	1	Trimmed galvonometers in Develocorders no. 1, 2 and 4
	2-8	Began preparations for installation of DMCF and auxiliary processors
	12	Z1 cable replaced
	12-15	Performed dc pulses to all seismometers
	18	Replaced damping pot on Z17
	23	Ran dc pulses on all short-period seismometers and preventive maintenance performed on LP Develocorder
	26	LPN mass was pegged and recentered
	28	Worked on data line termination module at Z17
January	2	Performed preventive maintenance on Develocorders 1 and 3
	6-12	DC pulses to all seismometers
	10	Beckman regulator and power control unit inoperative after several power fluctations; both units repaired temporarily until new parts are available
	12-21	Beckman regulator inoperative; tapes and PTA's operating from Sola transformer; regulator temporarily repaired
	20-26	Z2 intermittantly inoperative; data cable replaced on 26th
	26	LPN vault operned and resealed with new gaskets
	26	IB seismometer brought in to CRB
	27	Pulses run and polarity checked on Z2
	30	DCM replaced on Z5; pulses run and polarity checked on Z5

2. MCF "Coefficient Loss Problem"

Since the basic MCF processor was installed in March 1966, sporadic loss of filter coefficients caused problems until the unit was taken off-line in September 1966 for interfacing with the auxiliary processor. A lengthly discussion of the problem and a fix circuit were presented in CPO Quarterly Report No. 4.[1]

During the reported quarter a "no delay" fix was installed in the Dressen Barnes power supply and was laboratory tested.* Results of the installation and laboratory tests are presented in Appendix A. Briefly, these tests demonstrated that the fix circuit allowed the processor to survive a type of transient which had previously been found to cause coefficient losses.

After installation of the fix circuit, the MCF and auxiliary processors were installed again at CPO and were operational on 20 December 1966. At the field site, coefficient losses were still experienced sporadically. Further investigation revealed that losses were due not only to short power line transients but also to a severe ground loop problem.

The following modifications were subsequently incorporated into the processor system on 9-11 January 1967.

- The paper-tape reader logic ground connection was moved inside the MCF to the terminal strip which supplies power to the auxiliary processor. The processor ran without coefficient losses, but losses occurred on connecting and disconnecting the tape reader.

---

*Note: The fix described in Quarterly Report No. 4 required a 100-msec delay. This delay was undesirable due to data loss.

- The logic power wiring was moved to the paper-tape reader so it was not routed through the controller drawer. The three cabinets were grounded also. The tape reader could then be disconnected and reconnected without loss.

- The printer logic ground was removed to the controller drawer and reconnected at the power supply. Printer ribbon reversal now occasionally cycles the MCF through stop mode but does not cause coefficient loss.

Since incorporating these grounding changes into the system, further loss of coefficients has not occurred. However, it has been discovered that a coefficient loss could occur if a floating oscilloscope (or other test equipment) is connected to an internal MCF logic ground point. This can be prevented by having the equipment grounded externally to the MCF before the internal ground connection is made.

C. QUALITY CONTROL

Routine quality control of magnetic tapes and Develocorder film has continued as outlined in Quarterly Report No. 1.[2]

These checks have shown the film data to be in good condition and the analysis forms to be accurate and complete. The magnetic tape data was in good condition with very few spikes appearing on the tape checks.

Although film and tape data have been of high quality during the past quarter, quality control checks will be emphasized during the remainder of the contract to insure that the station instrumentation will be properly operating at the termination of the contract year.

SECTION III
RESEARCH

This section reviews the research performed during the reported quarter under the CPO contract. The research is discussed in three parts:

- Continuation of the ambient noise study
- Evaluation of the MCF
- Improvement of visual data display

A discussion of the research related to the auxiliary processor is presented in Section IV.

A. AMBIENT NOISE STUDY

This subsection presents the results from the continuation of the ambient noise study, comparing the present properties of the ambient noise field with those noted previously. The data presented in this report are from September and October 1966 and generally show the time stationarity of the noise field over the time period from 1965 to 1966.

1. Single-Channel Power-Density Spectra

Figures III-1 and III-2 present the single-channel power-density spectra computed from Z10 for September and October 1966. These spectra show only minor deviations from those presented in Quarterly Report No. 3[3] and other previous quarterly reports. Comparing the spectra from a single channel shows that, since no major deviations are present, the noise field has remained time stationary.

2. Frequency-Wavenumber Spectra

The data presented in the 3-dimensional frequency-wavenumber spectra for 28 September 1966 (Figures III-3 and -4) and for 15 October 1966 (Figures III-5 and -6) do not differ significantly from those presented in previous quarterly reports.

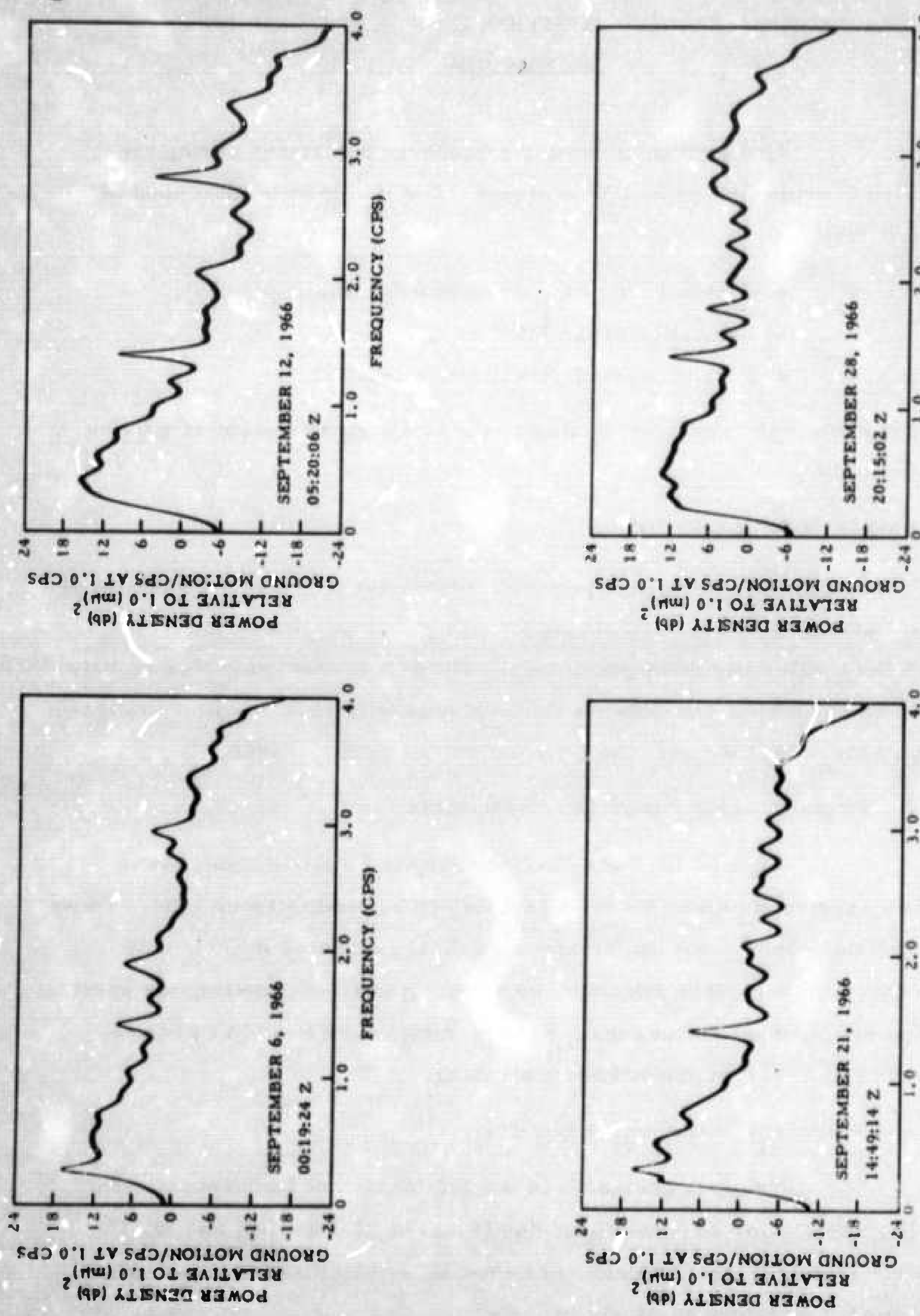


Figure III-1. CPO Ambient Noise Power-Density Spectra for September 1966

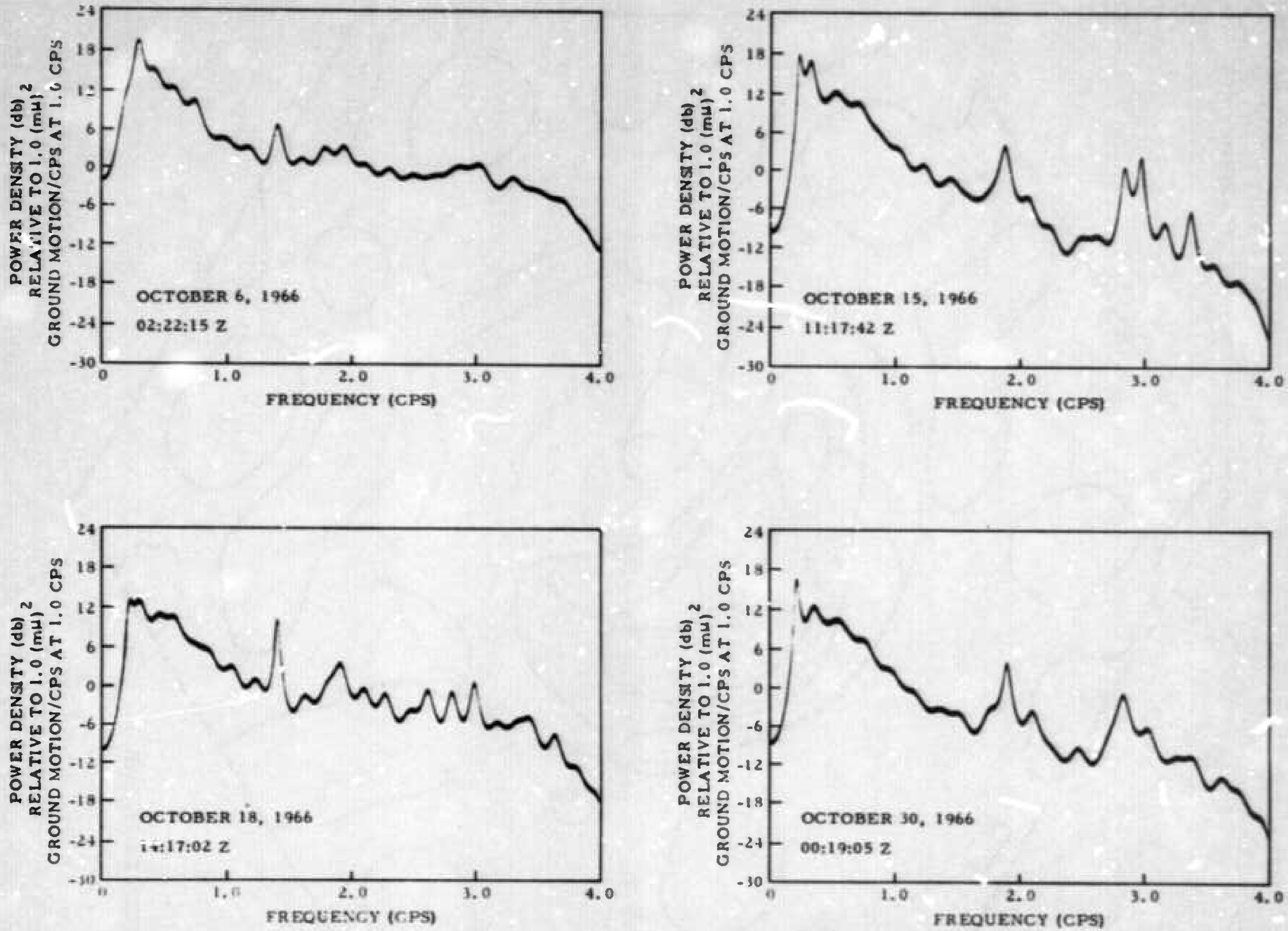


Figure III-2. CPO Ambient Noise Power-D nsity Spectra for October 1966

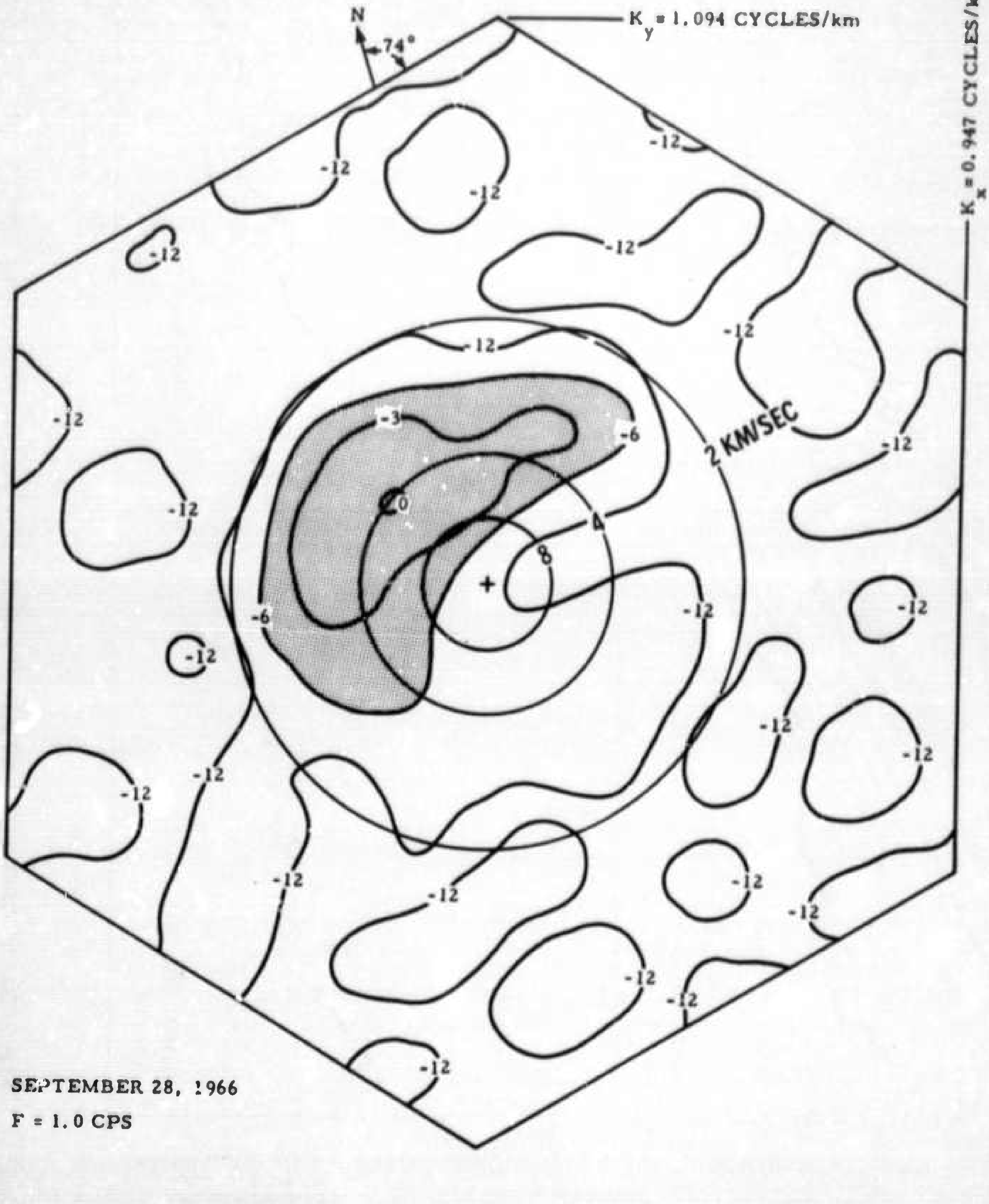


Figure III-3. CPO Ambient Noise Frequency-Wavenumber Spectrum 28 September 1966 (f = 1.0 cps)

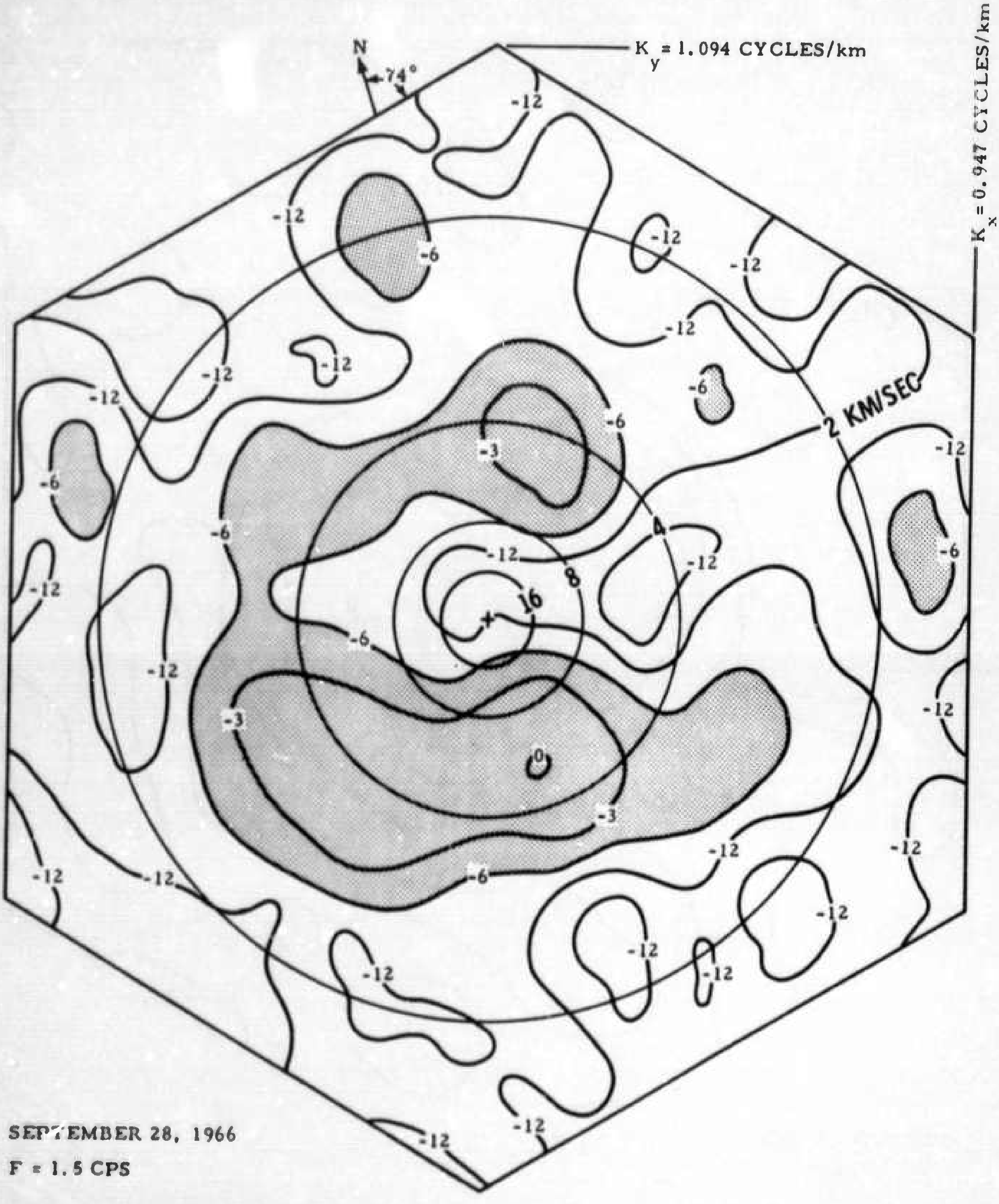


Figure III-4. CPO Ambient Noise Frequency-Wavenumber Spectrum 28 September 1966 (f = 1.5 cps)

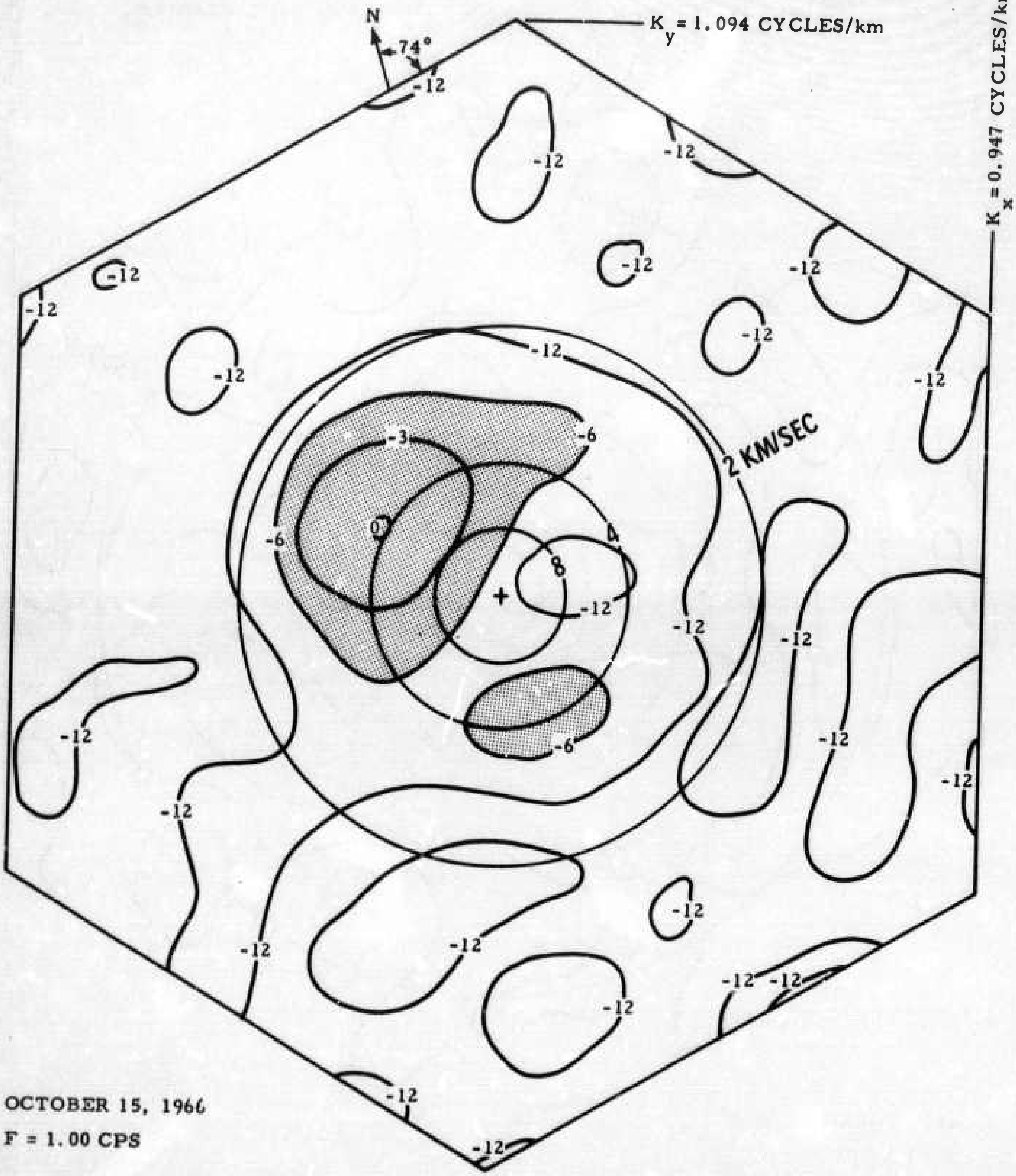


Figure III-5. CPO Ambient Noise Frequency-Wavenumber Spectrum 15 October 1966 (f = 1.0 cps)

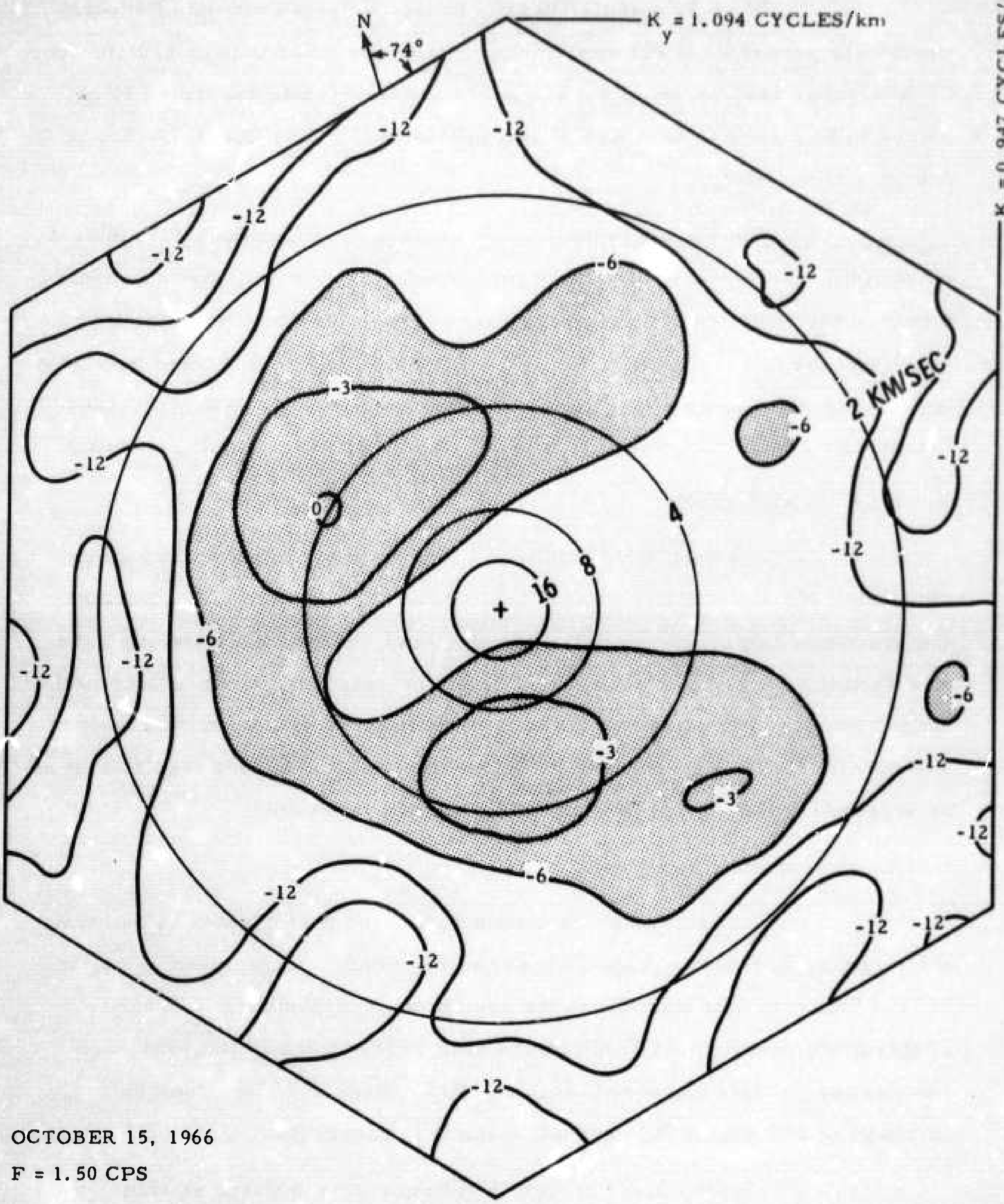


Figure III-6. CPO Ambient Noise Frequency-Wavenumber Spectrum
15 October 1966 (f = 1.5 cps)

The only notable change in these spectra from most spectra previously presented is the spreading of the major noise lobe at 1.0 cps for 28 September 1965 shown in Figure III-3. However, this spreading is not unique to this spectra as it was shown previously in CPO Quarterly Report No. 3, Figure III-2.

Figures presented in this section show that the CPO ambient noise field has remained relatively time stationary; i.e., it has not changed significantly from the preceding contract year. Therefore, the filters developed for use last year in the DMCF are still accurate for use on normal-level noise days and are the ones now being used in the digital processor. (Subsection IV-C2 discusses the present processor programming modes.)

B. MCF EVALUATION

The goal of this study is to evaluate the increase in station detection capability afforded to the analysts at CPO by the MCF. During the preceding two quarters, data from July and August 1966 were analyzed to determine the percent increase in detection capability using data from the DMCF compared to using raw data. July results showed an increase of 195 events (63.725 percent) using the processor,[1] and August results showed an increase of 165 events (46 percent)[4] using the processor.

1. Presentation of Data

This study was continued during the past quarter to determine the increase in detection capability during the month of September using the MCF. The complete lists of events are shown in Appendix B. Results of this study are given in Table III-1 which shows the daily total for each list and the percent increase using the MCF. Results of the study show an increase of 201 events (59 percent) using the processor.

Figures III-7 through III-11 show events which station personnel detected only on the MCF output.

Table III-1

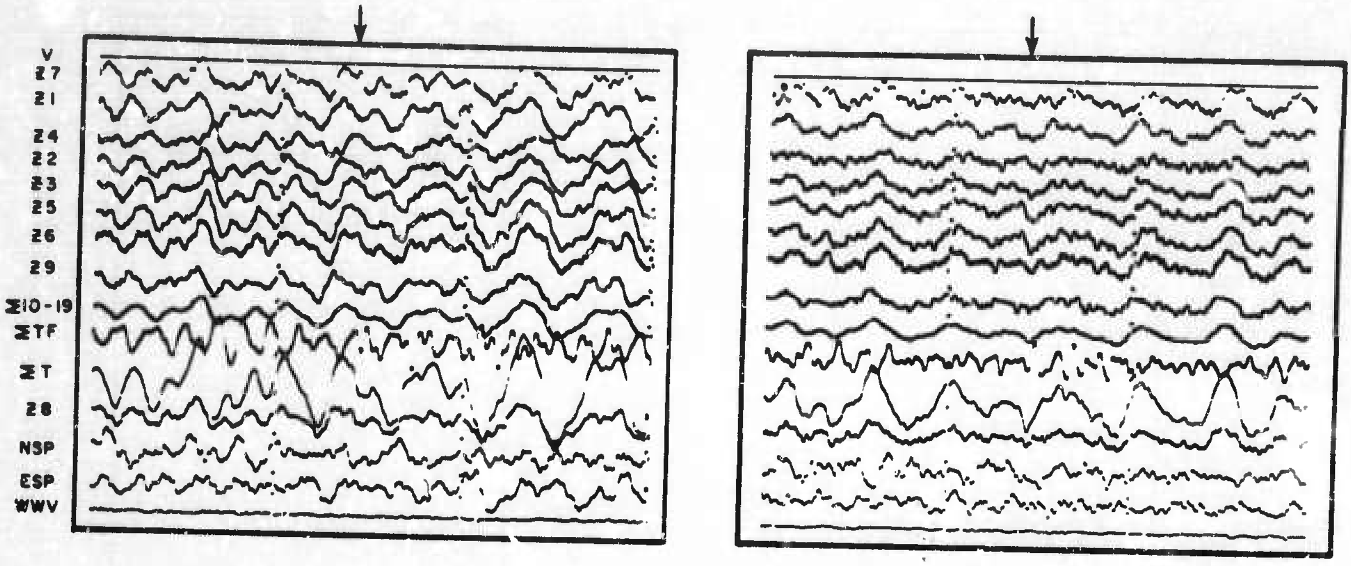
CPO MCF OUTPUT STUDY, SEPTEMBER 1966

Date	Number of Events Reported without MCF Data	Number of Events Reported with MCF Data	Percent Increase in the Number of Reported Events with MCF
01	18	24	33
02	16	25	56
03	10	15	50
04	16	22	38
05	15	33	120
06	18	30	67
07	*	19	
08	16	23	44
09	17	22	29
10	17	32	88
11	*	27	
12	12	24	100
13	10	13	30
14	*	13	
15	24	35	46
16	7	16	129
17	12	19	58
18	16	18	13
19	10	18	80
20	12	19	58
21	7	19	171
22	23	27	17
23	13	19	46
24	*	15	
25	13	19	46
26	4	12	200
27	10	17	70
28	8	15	88
29	12	21	75
30	13	13	
Total	349	550	59

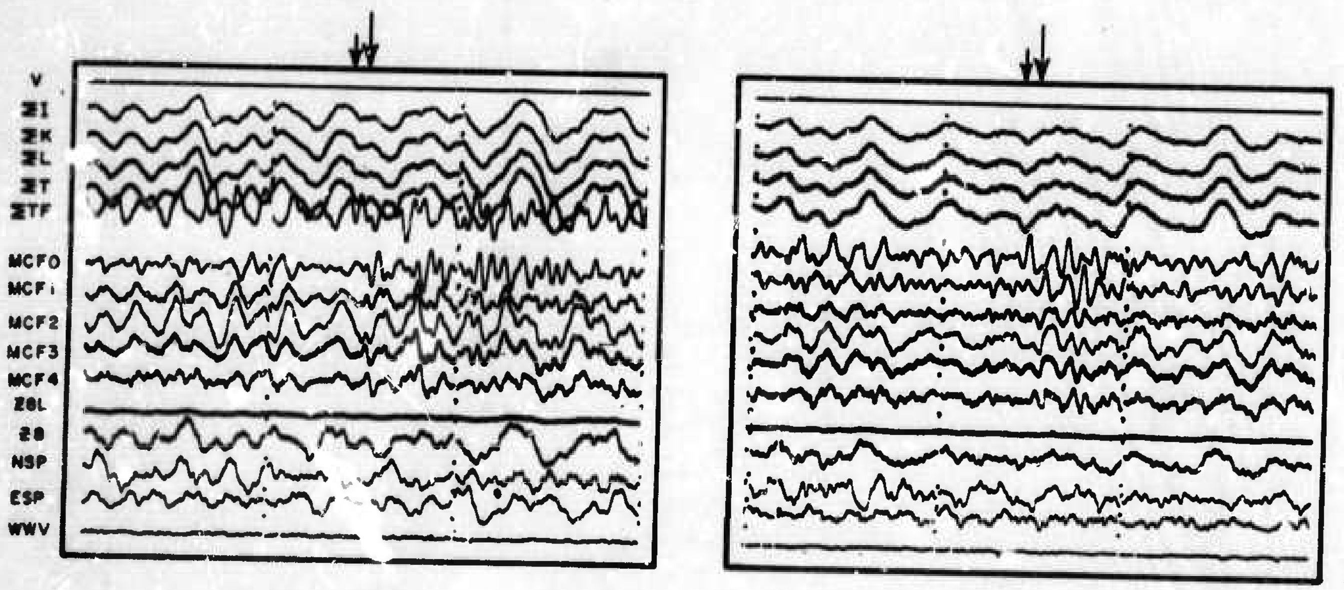
*No data available (total does not include result for days when no data were available for column without MCF data)

09:42:14.0

08:57:44.0



PRIMARY



SECONDARY

SEPTEMBER 1, 1966

SEPTEMBER 2, 1966

Figure III-7. Primary and Secondary Develocorder Records

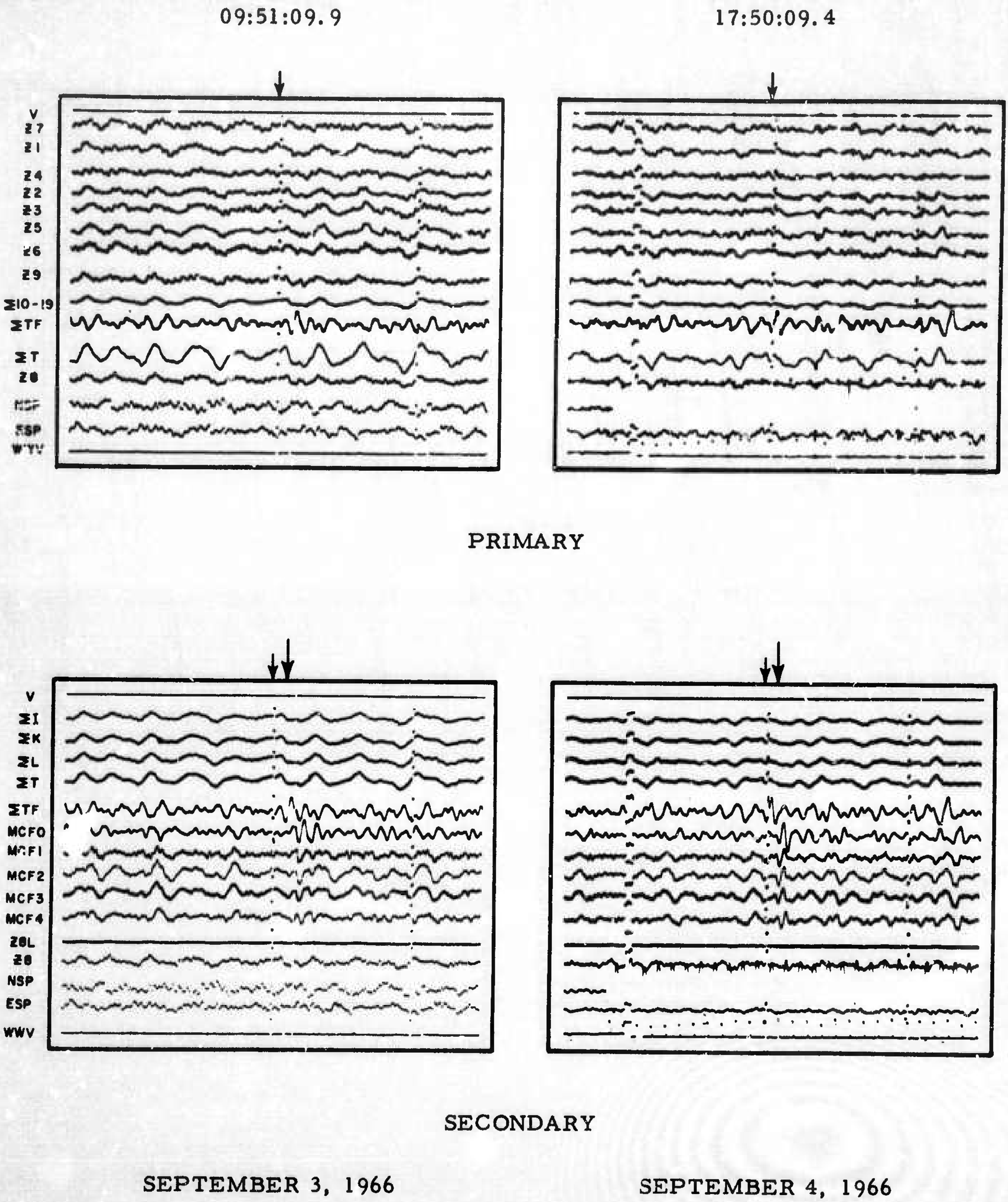


Figure III-8. CPO Primary and Secondary Develocorder Records

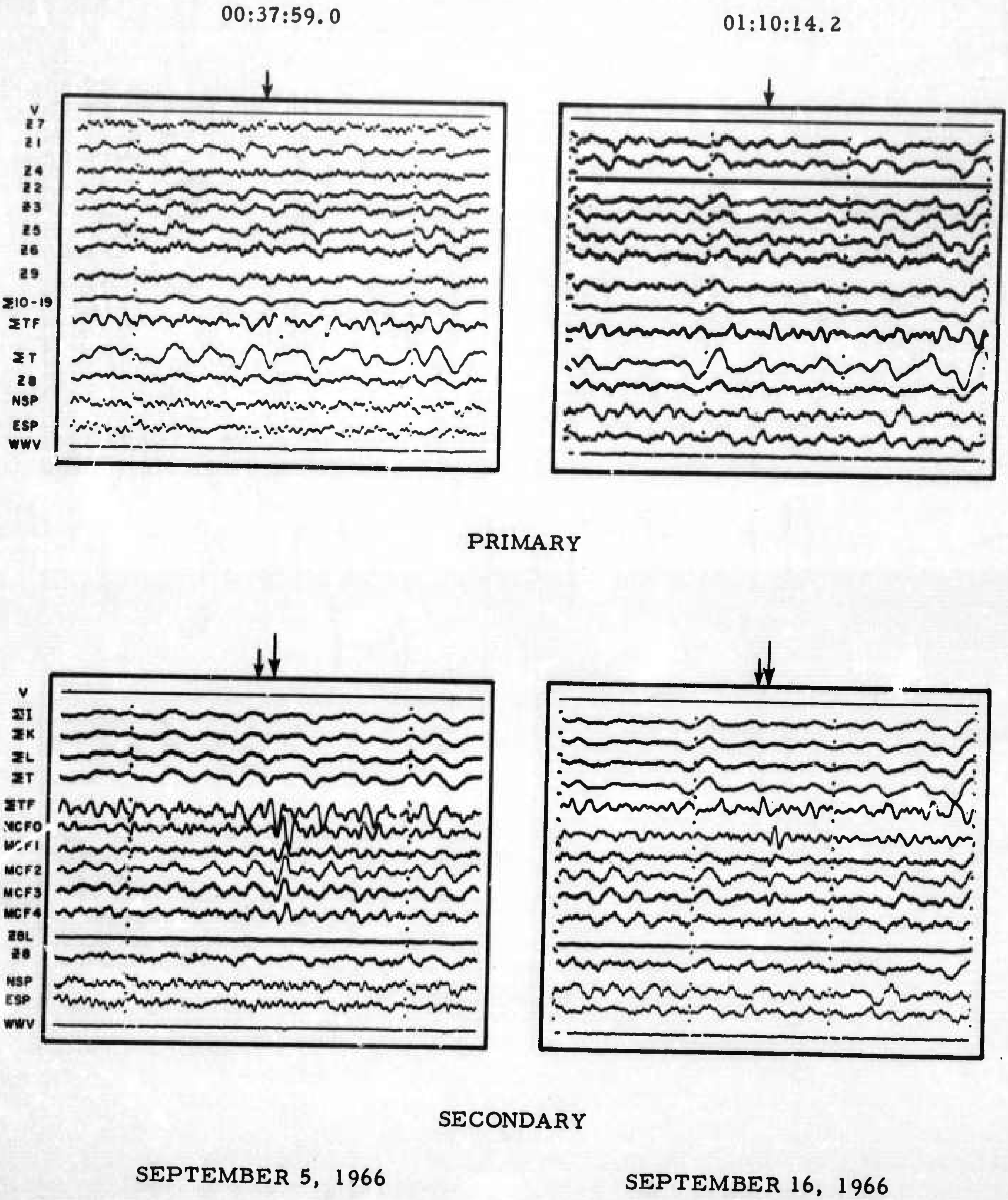


Figure III-9. CPO Primary and Secondary Develocorder Records

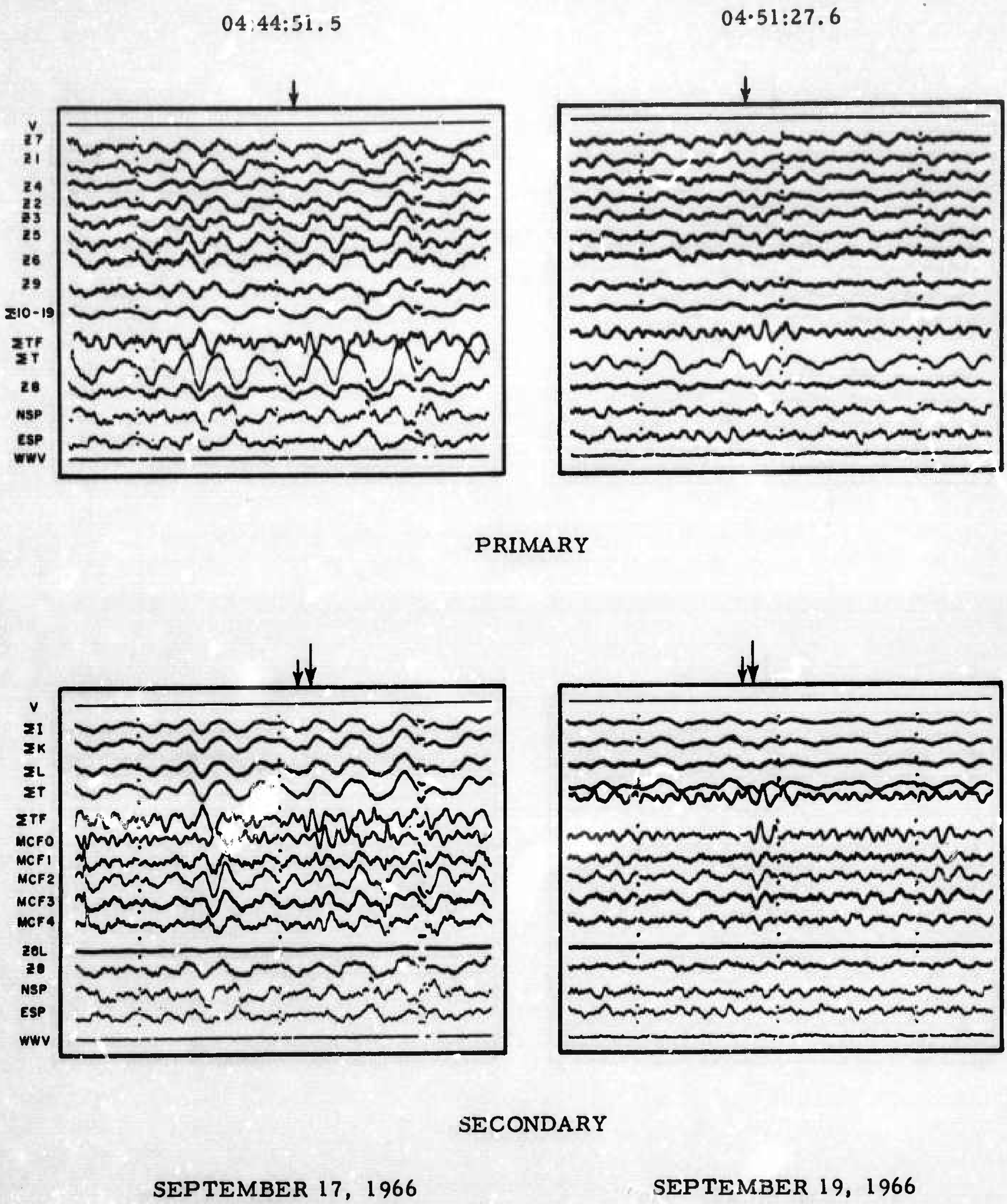


Figure III-10. CPO Primary and Secondary Develocorder Records

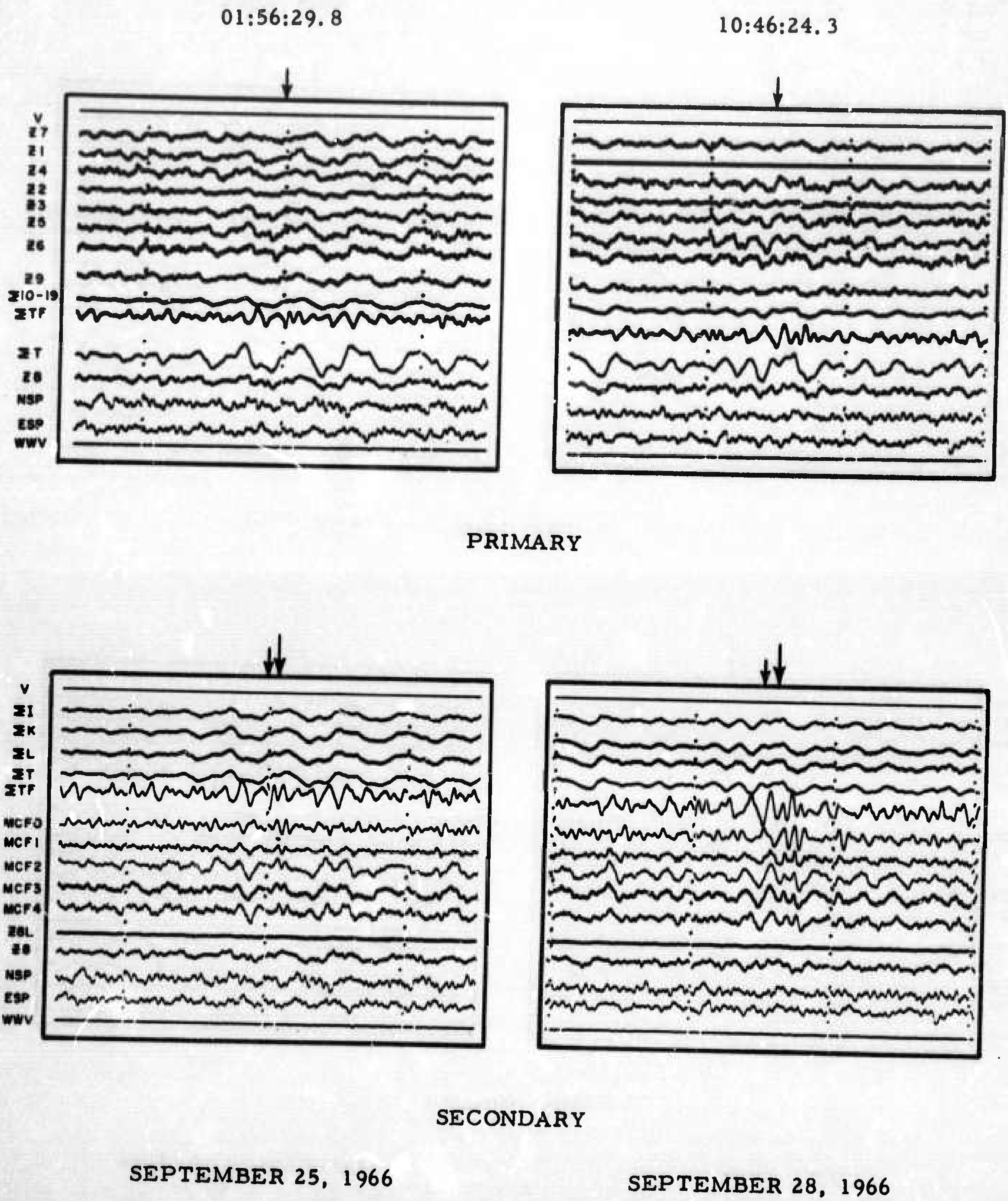


Figure III-11. CPO Primary and Secondary Develocorder Records

These figures demonstrate the advantage given to station personnel by the MCF. Station time of each P-wave arrival is shown by the small arrows, while the first motion of the P-wave arrival on the MCF outputs (which are delayed by 0.85 sec) is shown by the large arrows.

2. Discussion of Recent Results

Evaluation of the increase in detection capability afforded analysts by the MCF processor over a 3-month period (July, August, September 1966) has shown that the total number of events detected with the processor increased 55.4 percent over the number detected without processor data (Table III-2). The average number of events detected before the MCF was used (May 1965 through April 1966) was 305 per month. This average rose to 626 per month while the MCF was operational (May 1965 through September 1965).

When the MCF processor was taken off-line at CPO on 30 September 1966, it was expected that the monthly average number of detected events would decrease substantially to around 330 to 340 (assuming that the worldwide seismicity level remained constant). Table III-2 shows that this was not the case. This table shows a monthly average of 588 events from October 1966 through January 1967, indicating only a slight decrease from the period during which the MCF was operational (626 events monthly).

Either of two things could occur which would explain this deviation from the prediction; either the seismicity level could have increased, or analysts were for some reason picking more events than prior to MCF installation. Combinations of the two could also occur. Both possibilities were thoroughly investigated with the following conclusions:

- From USC&GS 1966 data, the seismicity level appeared to have remained fairly constant throughout the year with approximately 400 events per month reported over the period January 1966 to October 1966

Table III-2

TELESEISMIC EVENTS DETECTED PER MONTH

Month	Without MCF	With MCF
May 1965	281	—
June 1965	375	—
July 1965	318	—
August 1965	319	—
September 1965	250	—
October 1965	308	—
November 1965	315	—
December 1965	271	—
January 1966	272	—
February 1966	329	—
March 1966	399	—
April 1966	461	—
May 1966	—	644
June 1966	—	699
July 1966	306*	501* (555)
August 1966	358*	523* (599)
September 1966	349*	550* (635)
October 1966	601	—
November 1966	565	—
December 1966	567	—
January 1967	619	—

*Missing 2 to 4 days data during month

- From data recorded at UBO, it was shown that the seismicity level at that station remained relatively constant during the time period from January 1966 to January 1967, with a monthly average of approximately 1850 events.*
- Station analysts felt they were better qualified to identify secondary data low-level events as a result of experience gained with the MCF processor
- Station analysts were now using secondary data for their prime analysis, while prior to the MCF installation primary data was used almost exclusively

The last two conclusions are related because, during the period that the MCF was operational, MCF data was placed on the secondary Develocorder along with the various summation traces. This allowed an unconscious, ready comparison on the part of the analysts between MCF and secondary data. Thus it appeares that the number of reported events did not drop when the processor was removed from CPO because the analysts picked more low-level events as a result of using the secondary data for prime analysis and also because of the experience gained when the MCF was operating on-line.

C. IMPROVEMENT OF VISUAL DATA DISPLAY

This task's purpose is to develop a technique to aid station analysts in their interpretation of Develocorder records. Two methods were discussed and results were presented in Quarterly No. 5.[4] The other method, a single-channel filter technique, was briefly mentioned in the same report and will be discussed in detail in this report.

*Data furnished courtesy of the Geotechnical Corporation, Garland, Texas.

1. Presentation of Data

This study was directed toward developing single-channel filters to be used in the MCF to remove system response from Develocorder records. Filters were developed for amplitude and velocity response removal (discussed in Quarterly Report No. 5).[4]

The filters that were developed are shown in Figures III-12 and III-13 for the amplitude and velocity removal techniques, respectively. The filters were 39 and 200 points in length; or 1.95 sec and 10.0 sec. The conclusions drawn from these figures are that filters of at least 200 points in length would be required to successfully perform this task, and that these filters would probably still not give a good approximation of the desired results.

2. Conclusions

Due to the fact that extremely long filters are necessary for this task and these filters would require more core space in the MCF than is available under the present programming mode, it is recommended that this method of approaching the task be discontinued.

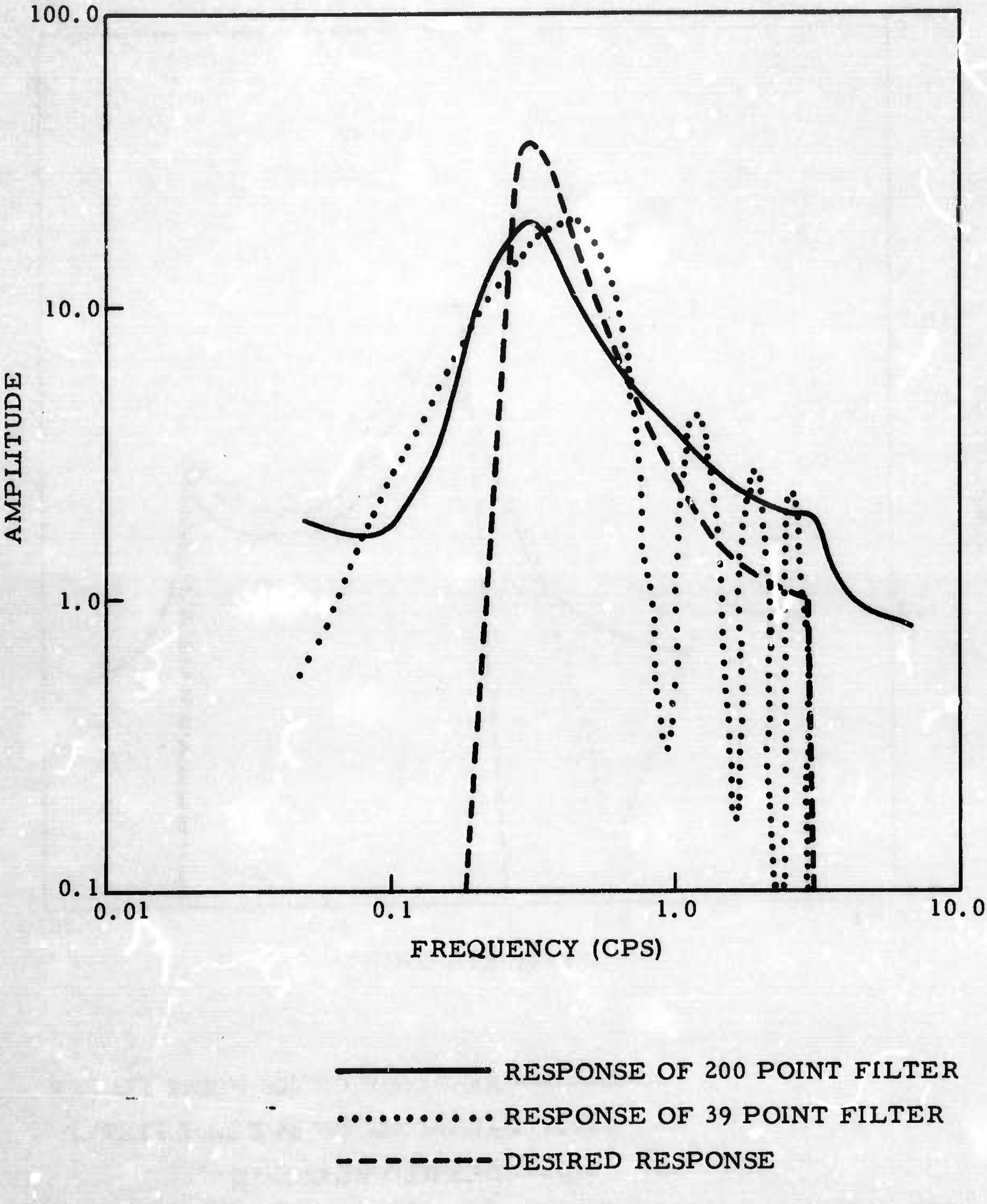


Figure III-12. Responses of the CPO Amplitude Removal Filters

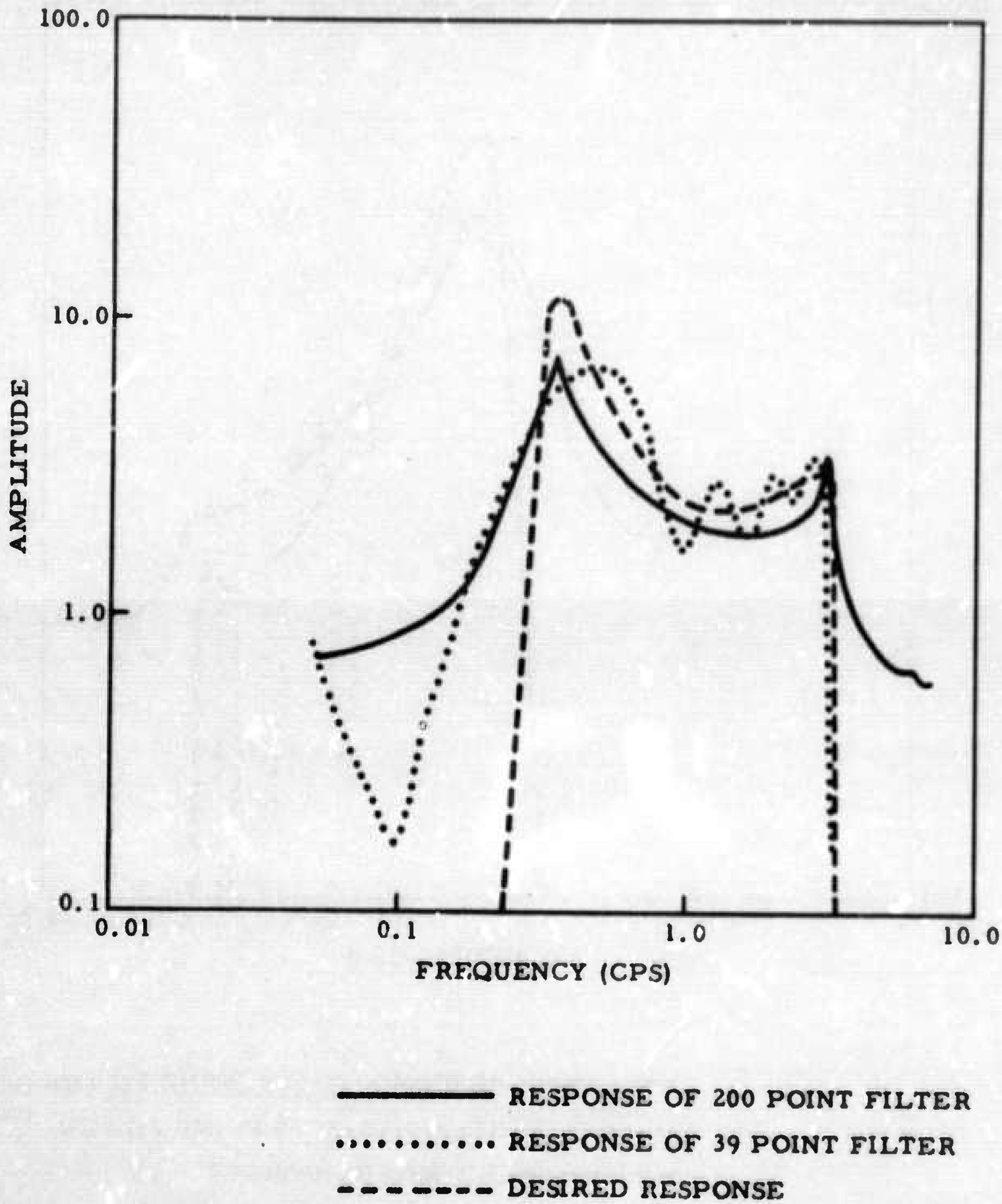


Figure III-13. Response of the CPO Velocity Removal Filters

SECTION IV
AUXILIARY PROCESSOR

A. GENERAL

Under this contract, efforts have been directed in part toward the design, construction, checkout, installation, on-line operation and evaluation at CPO of a detection and identification processor. This processor computes Fisher and Wiener sum-of-squares detection outputs and UK identification outputs. The unit interfaces with the existing MCF processor and shares available data core storage and computing capability.

The main purpose for constructing this auxiliary processor was to study the implementation and use of automatic on-line detection hardware. This on-line automatic detection capability now makes it economically possible to collect and evaluate enough data to, in turn, evaluate on-line processing techniques. Before a worldwide network of seismic arrays can be established, automatic on-line detection hardware is necessary because of the large quantities of data which must be reduced to an economically manageable level.

The device, which has been operational at CPO since 30 December 1966, evaluates automatic detection by using "yes-no" type threshold detectors which continually monitor the Fisher and Wiener detection outputs.

The following subsections describe the hardware, on-line implementation at CPO, evaluation to be performed, and Dallas-based research support necessary to effectively use and evaluate the processor.

B. SYSTEM DESCRIPTION

1. Introduction

The auxiliary processor performs the Fisher, United Kingdom and Wiener power processes. In addition, the auxiliary processor provides digital threshold detectors on the Fisher and the Wiener power outputs.

The auxiliary processor (Figure IV-1) performs these supplementary processes without increasing memory capacity or slowing the normal filtering processes of the CPO multichannel filter system. The auxiliary processor monitors the CPO multichannel filter processor and intermittently interrupts it to store data. Its routines utilize the CPO multichannel filter memory, multiplier, output registers, and several other circuits. Control signals, basic clocks and dc voltage (excluding digital-to-analog converter power) for the auxiliary processor are also supplied by the CPO multichannel filter system. The auxiliary processor provides digital-to-analog converters for one Fisher output, two United Kingdom outputs and four Wiener power outputs.

2. Basic Operational Description

This subsection presents the mathematical description of the operations performed by the three processes of the auxiliary processor and describes the threshold detectors.

a. Fisher Process

The Fisher process is a statistical signal detection process which operates on the filtered outputs of each MCF input channel. The filtered outputs are formed by the MCF in the beam-steer process using the following equation:

(Text contd IV-4)

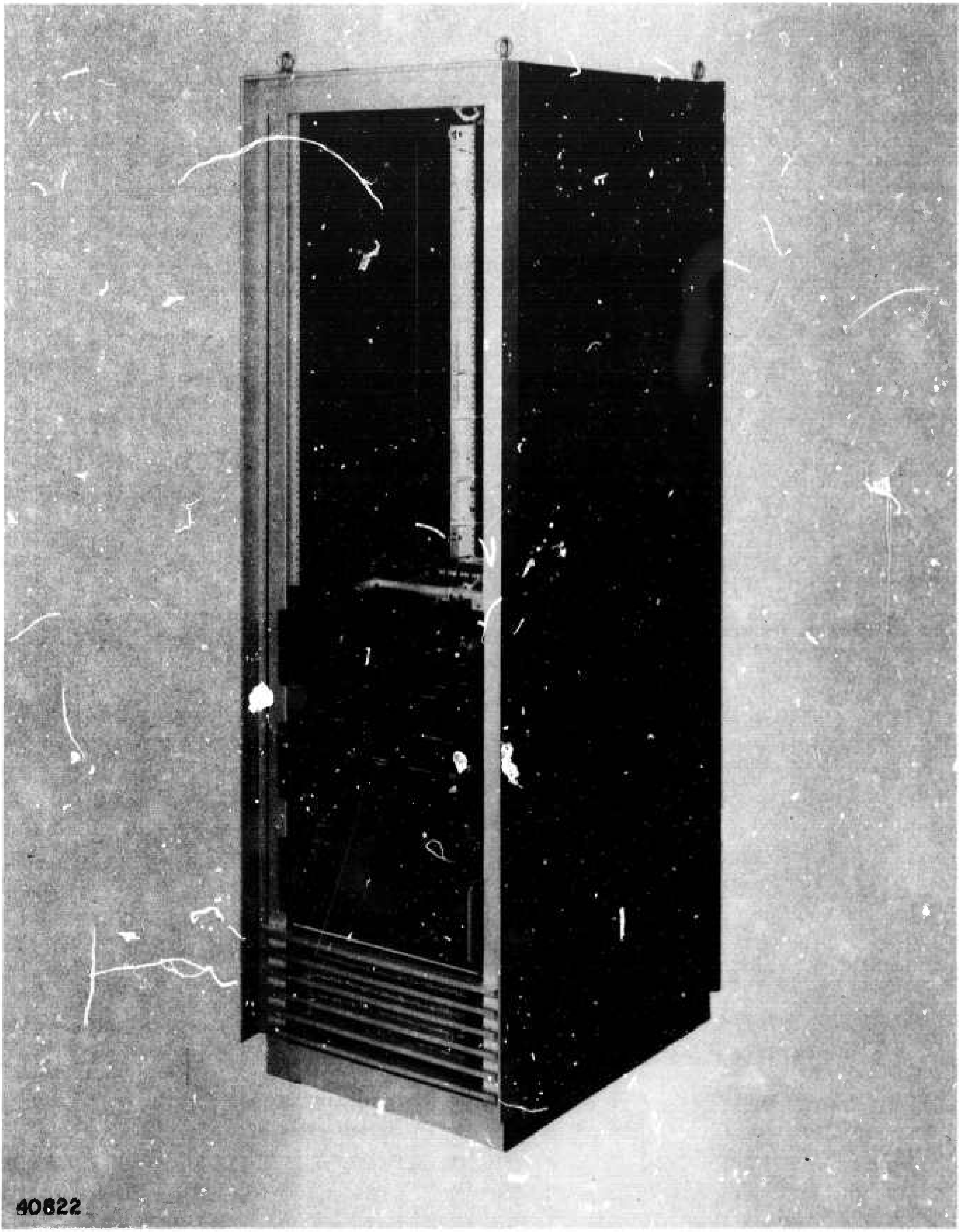


Figure IV-1. Auxiliary Processor

$$B_n^k = \sum_{i=0}^{I} S_{n-i}^k \, a_i^k$$

where

S_n^k is the value of the most recent sample of the data for input channel k (where k ranges from 0 to k)

a_o^k through a_i^k are constants

and

$I + 1$ is the number of filter points

By using the CPO multichannel filter hardware, the auxiliary processor computes a Fisher output according to the following equation:

$$\text{Fisher Output} = \frac{N1\left(K3 - \frac{K1}{P}\right)}{\left(K3 - \frac{K1}{P}\right) + N2\left(\frac{K2}{2^{2x}} - \frac{K3}{K+1}\right)}$$

where

N1 and N2 are normalization constants

K + 1 is the number of input channels

P is the Fisher history length

x = 13 - y, where y indicates the position of the Fisher summation truncate switch

K1, K2, and K3 are referred to as the intermediate Fisher terms which are formed using the following equation:

$$K1 = \left(\sum_{p=1}^{P} \sum_{k=0}^{K} B^{k}_{n-(p-1)} \right)^2$$

$$K2 = \sum_{p=1}^{P} \sum_{k=0}^{K} \left(B^{k}_{n-(p-1)} \right)^2$$

$$K3 = \sum_{p=1}^{P} \left(\sum_{k=0}^{K} B^{k}_{n-(p-1)} \right)^2$$

The Fisher output computed by the processor is a transform of the true Fisher process which is given by:

$$F = \frac{K3 - \frac{K1}{P}}{K2 - \frac{K3}{K+1}}$$

Under highly coherent signal conditions, the denominator of F is zero, an undefined state for the hardware as implemented. To avoid this condition, F is transformed as follows:

$$\text{Fisher Output} = \frac{A \cdot F + B}{C \cdot F + D}$$

$$= \frac{(A/C)\,F}{F + D/C}$$

where

$$B = 0$$
$$A/C = N1$$
$$D/C = N2$$

The effect of this transform as a function of N2 may be seen in Figure IV-2. N1 sets the maximum value (routinely 777_8 or 512_{10}, the largest possible output number as a result of the 9-bit output register). Selection of N2 is normally based upon the F-value computed for the particular site's ambient noise field (at CPO, $F \cong 2.2$).[5] This may be determined operationally by finding one or two processor average ambient noise output values over a predetermined gate by using the Fisher threshold detectors and by reading the F value for the known N2.

b. United Kingdom Process

The United Kingdom process performs the zero-lag cross-correlation of two beam-steer outputs. The auxilliary processor forms two such outputs using the following equation:

$$\text{UK Output} = \sum_{p=1}^{P} C^{j}_{n-(p-1)} \quad C^{k}_{n-(p-1)}$$

where

$C^{j}_{n-(p-1)}$ = j^{th} beam-steer output of the MCF processor

(but $j \neq k$)

$C^{k}_{n-(p-1)}$ = k^{th} beam-steer output of the MCF processor

P = number of UK history points

n denotes the most recent beam-steer output, n-1 is the next most recent beam-steer output, etc.

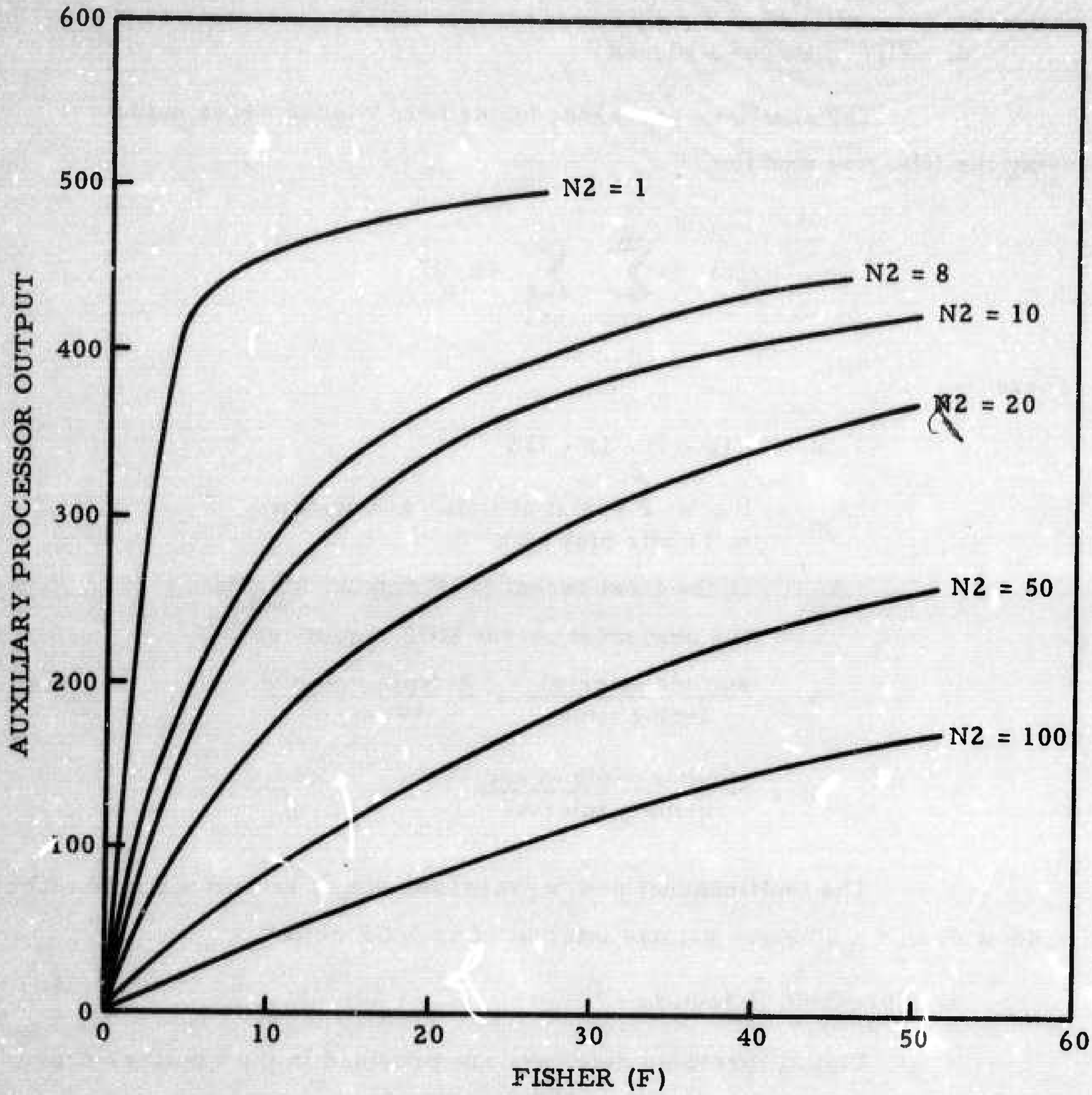


Figure IV-2. Fisher Transformation as a Function of N2

A second UK output is generated using outputs l and m, where l ≠ m and j, k, l, and m are not equal.

New UK outputs are computed every 50 msec.

c. Wiener Power Process

The auxiliary processor forms four Wiener power outputs using the following equation:

$$\text{Output} = \sum_{r=1}^{R} \sum_{s=1}^{S} (A_m)^2$$

where

$m = n(s - 1) - (r - 1)S$

A_m = the MCF output at time m, truncated to 11 bits plus sign

A_n is the most recent MCF output, A_{n-1} is the next most recent MCF output, etc.

$$S = \frac{\text{sample interval}}{\text{frame time}} = \frac{\text{sample interval}}{\text{50 msec}}$$

$$r = \frac{\text{window width in sec}}{\text{sample interval}}$$

The multichannel power processor output is an R x S x 50 msec window of an S x 50 msec sample interval of an MCF output.

d. Threshold Detectors

Digital threshold detectors are provided in the auxiliary processor for the Fisher output and the four power outputs. The threshold detectors provide a separate signal output when a monitored output equals or exceeds a switch selected level.

3. General Characteristics

The design philosophy and general appearance of the auxiliary processor were modeled after the basic MCF processor. The unit consists of an 80 in. single bay rack (Figure IV-1) containing three drawers: the arithmetic drawer (Figure IV-3a and -3b), the output drawer (Figure IV-4a and -4b) and the controller drawer (Figure IV-5). All input and output cabling passes through the top of the cabinet.

The spare rack in the auxiliary processor may be used for support equipment such as the paper tape reader (PTR), data control modules, standard station timing unit, and the rack mounted oscilloscope.

a. Input Signals

All input data signals are derived from the basic MCF processor as described in the following listing.

- Wiener Power Process

  This process derives its input from the MCF 1-4 outputs. Of the 24 available bits of data, 9 are selected using of the input data truncation switch.

- Fisher Process

  Single-channel data are accepted from the MCF 0 output. This allows single-channel prefiltering of data prior to computation of the Fisher statistic. Of the available 24 bits of data, 9 are selected through the Fisher input data truncation switch.

- UK Process

  The input is derived from two selectable beam-steer outputs. Nine of the total 24 available bits are selected by the UK input data truncation switch.

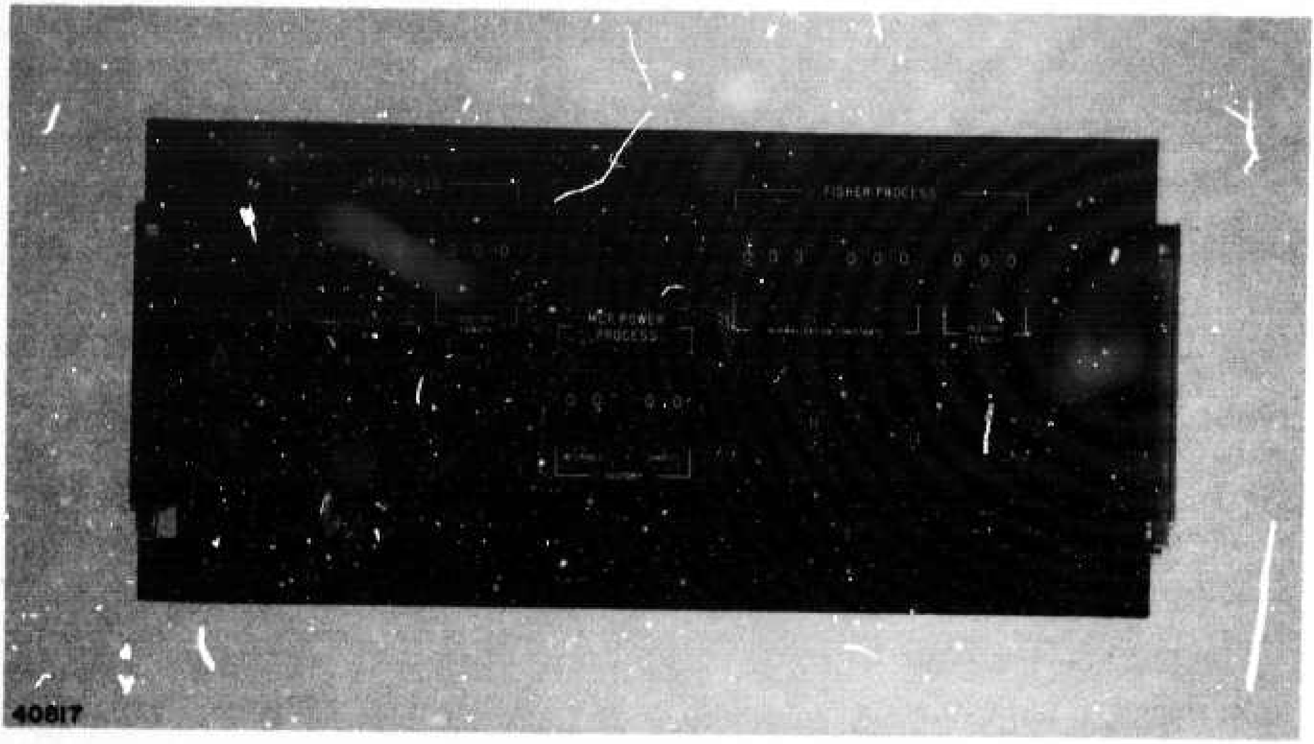


Figure IV-3a. Arithmetic Drawer Front Panel

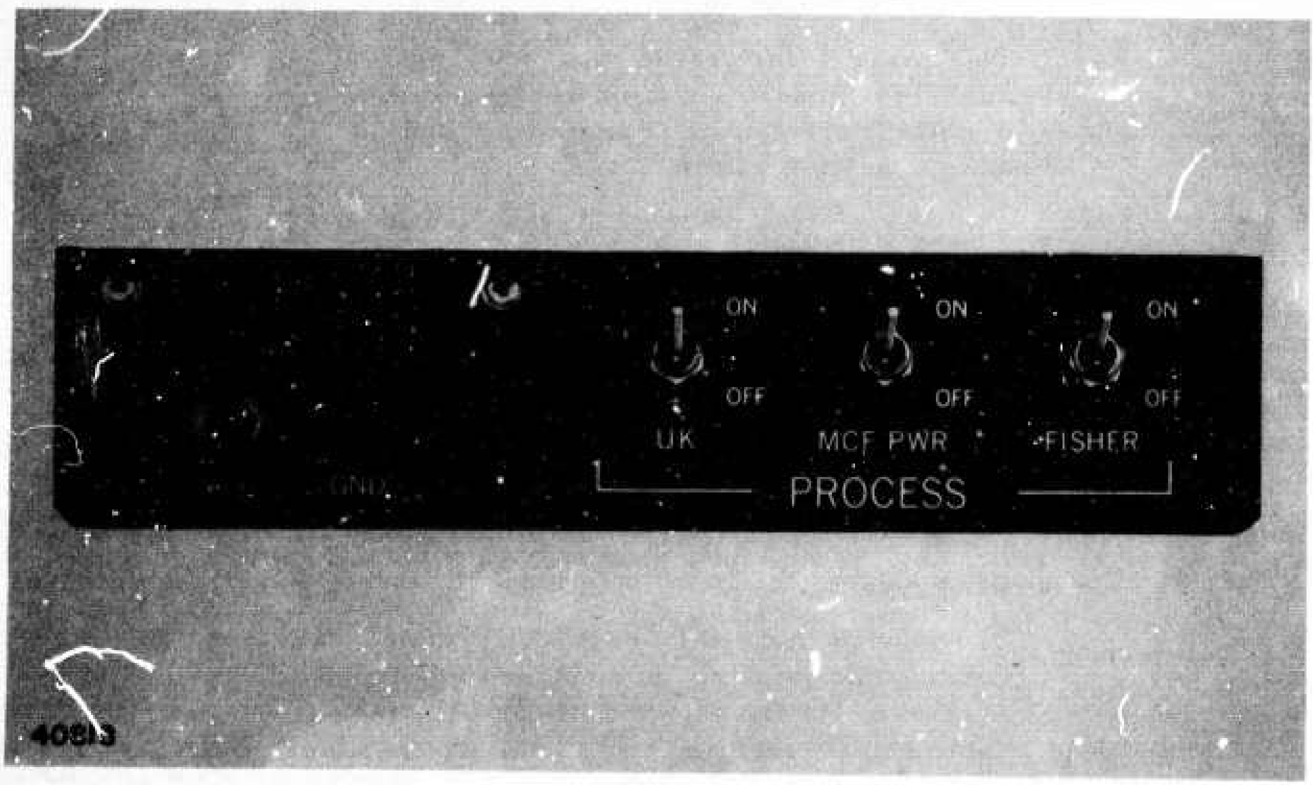


Figure IV-3b. Arithmetic Drawer Internal Switch Panel

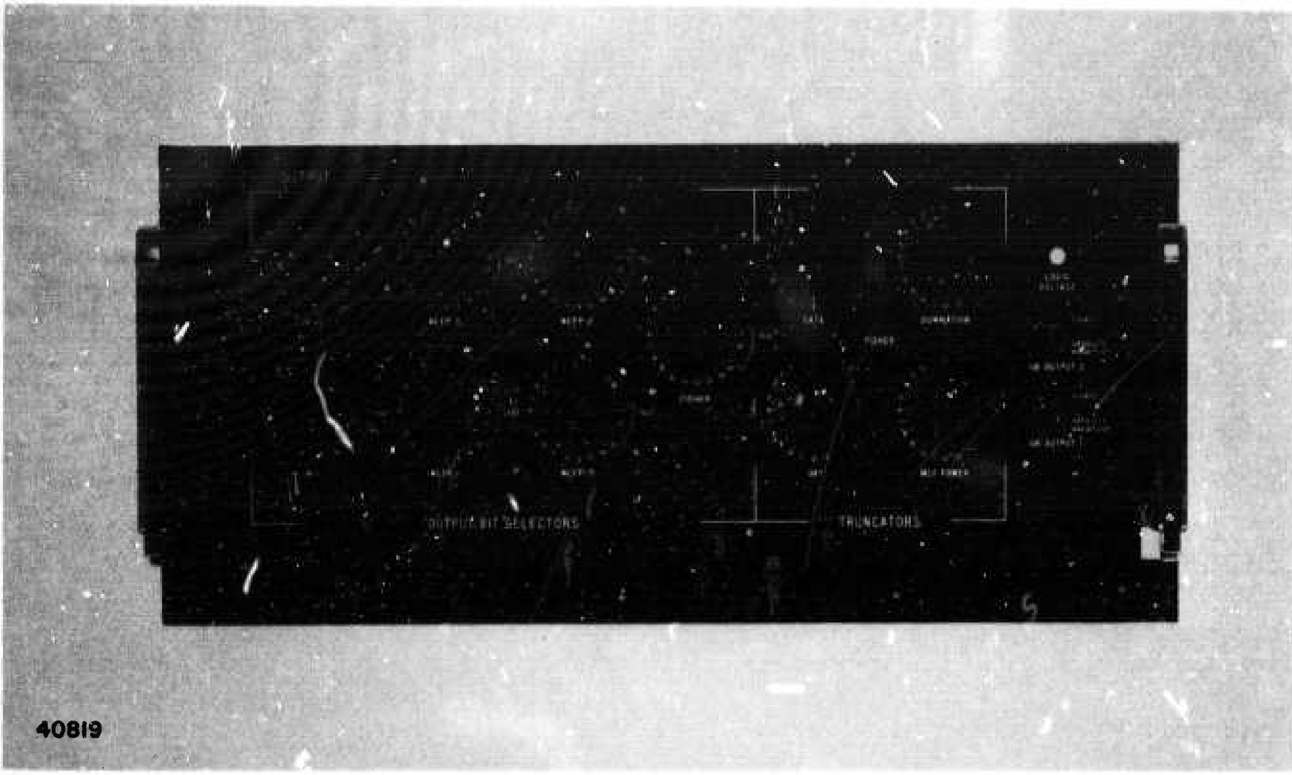


Figure IV-4a. Output Drawer Front Panel

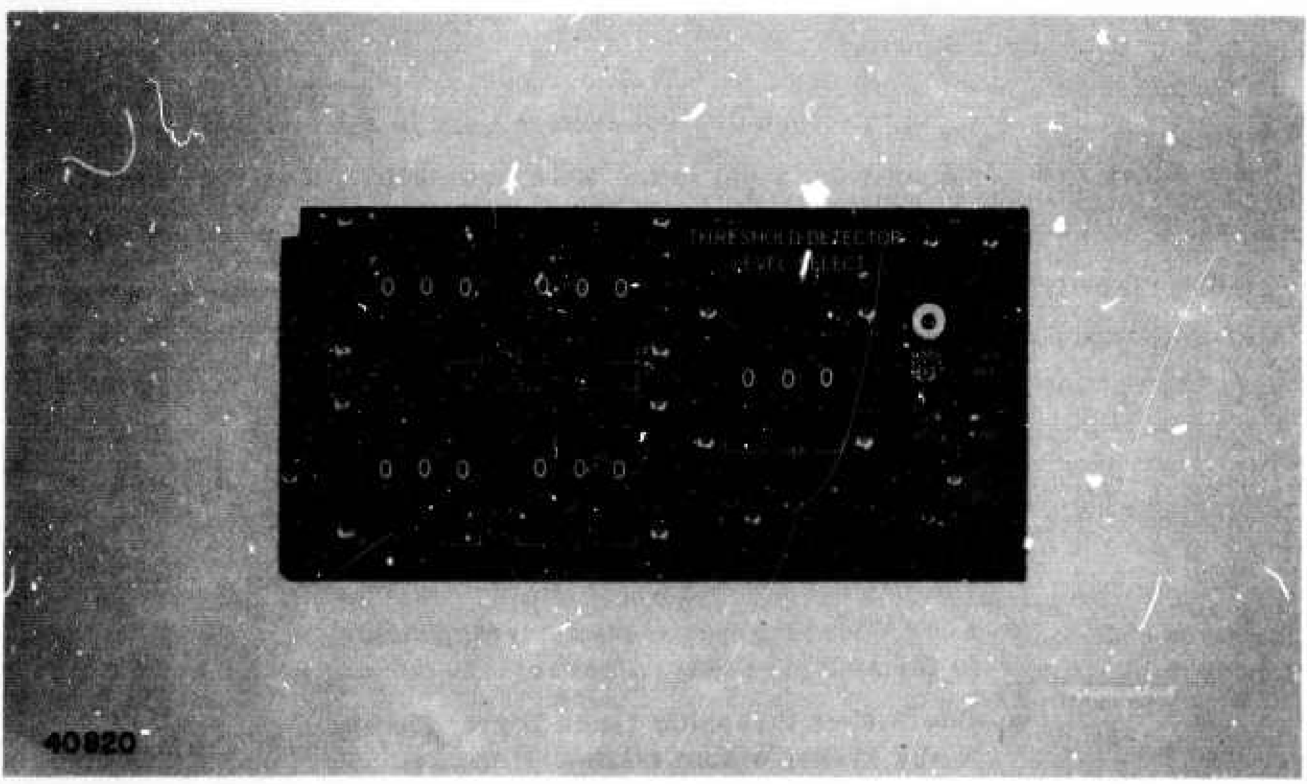


Figure IV-4b. Output Drawer Internal Switch Panel

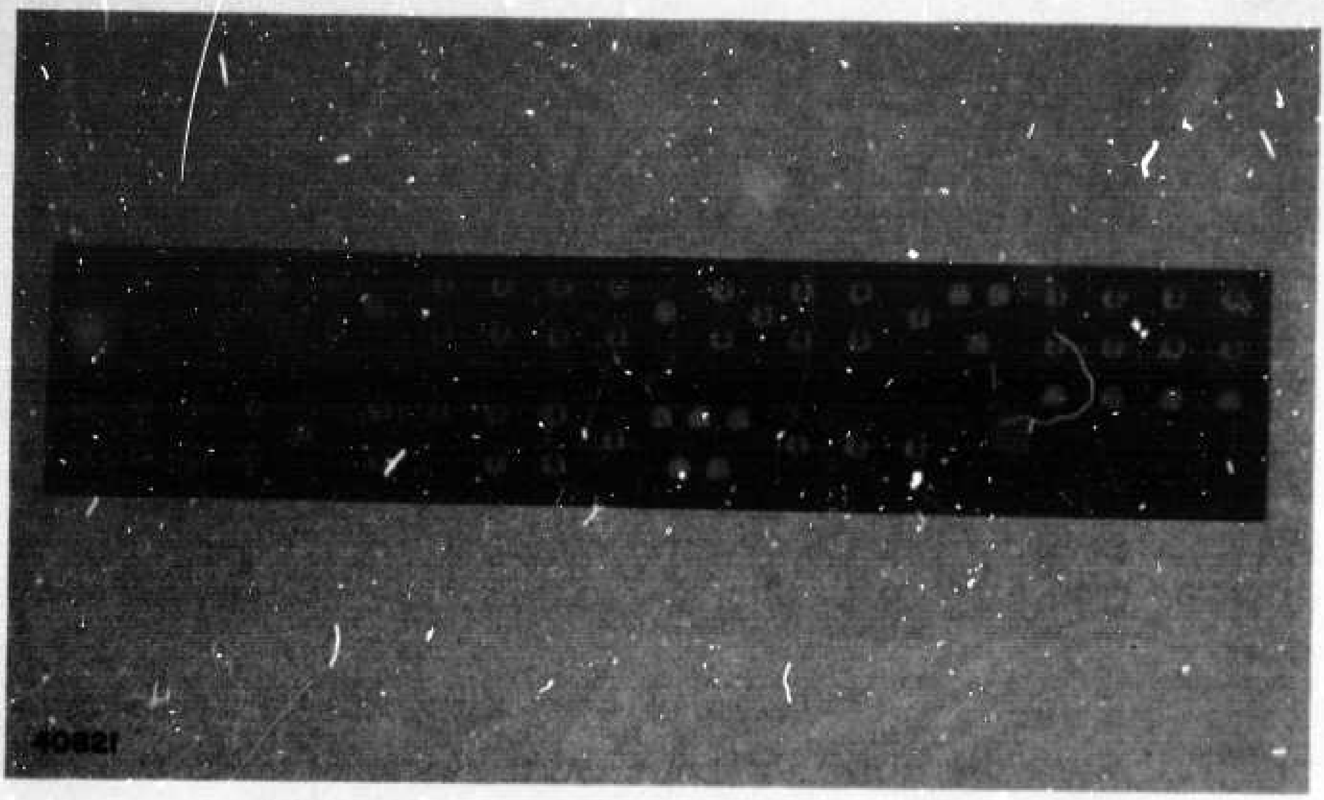


Figure IV-5. Controller Drawer Internal Display Panel

b. Output Signals

The digital-to-analog converters used in the auxiliary processor are of the same type as those used in the MCF processor. For the Fisher, Wiener power and UK outputs 9 bits plus sign are selected from the 25-bit output register using individual output truncation switches; thus giving an analog-type gain control in 6-db increments.

The processor outputs are summarized as:

- One Fisher output trace
- Two UK output traces corresponding to two programmed area locations
- Four Wiener power traces corresponding to the MCF 1-4 output traces
- One Fisher threshold trace corresponding to the Fisher output trace
- Four Wiener threshold traces corresponding to the four Wiener power traces

c. Program Selection

The following key variable programming modes are offered by means of panel mounted switches.

- Fisher Process

  Normalization constants N1 and N2 are variable from 0 to 777_8. History length (gate length of computation) may be selected from 0 to 999 points.

- UK Process

  History length is variable from 0 to 999 points, and selection of the 4 beam steers (2 each for UK0 and UK1) is provided.

- Wiener Power Process

  History length specifiable in "R" intervals, 0 to 99, and "S" samples, 0 to 99, where the gate is determined by R intervals of S samples each.

- Threshold Detectors

  Independently variable threshold levels are programmable from 0 to 777_8 (Figure IV-4b).

C. ON-LINE IMPLEMENTATION

1. Milestones

During this quarter the auxiliary and MCF processors were interfaced, checked out, shipped, and installed at CPO. This task's milestones reached during the past quarter are as follows.

Date	Activity
November 15	Completed design and construction of detection and identification processor
December 9	Completed check-out of interfaced processors
December 12-15	Installed and verified satisfactory laboratory operation of no-delay coefficient loss fix
December 16	Processors shipped to CPO from Dallas
December 19	Processors arrived at CPO and installation started
December 20	Processors operational at CPO, but difficulty encountered with Fisher process
December 30	Both processors on-line and operating properly at CPO
January 17	Successful acceptance test performed in presence of Project Monitor at CPO

Figure IV-6 shows the auxiliary and MCF processor installation at CPO.

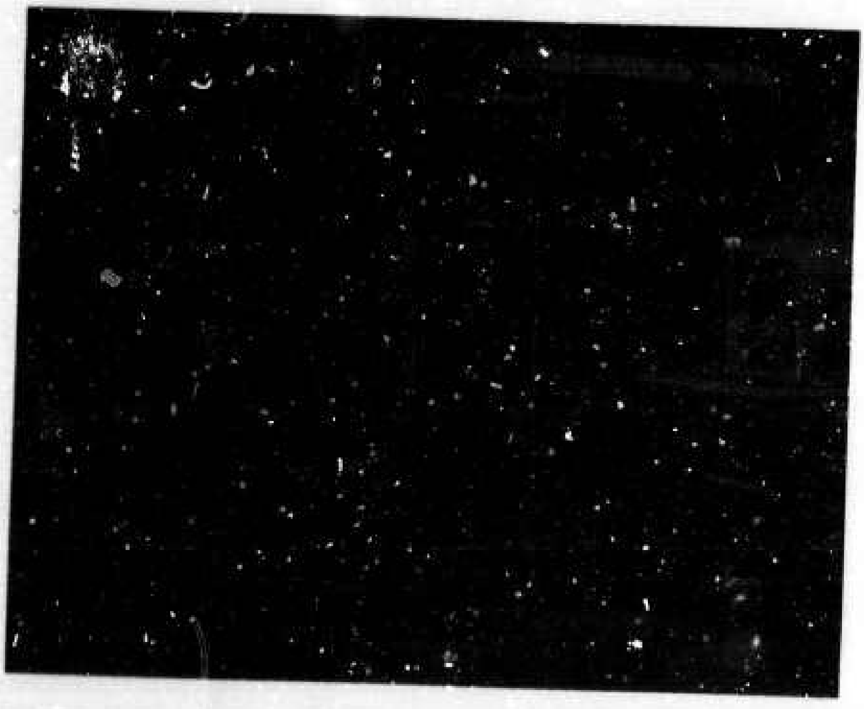


Figure IV-6. Auxiliary and MCF Processor Installation at CPO

2. Processor Operating Mode

In conjunction with processor installation, it was necessary to redevelop the tapes in order to reprogram the MCF with the coefficients previously used in the MCF. This was necessitated by the reduction in the amount of available core space when both processors were interfaced because the auxiliary processor required use of part of the MCF processor's core.

The present operating mode consists of eight beam-steers, one prefilter, and four MCF's as shown in Table IV-1. The beam-steer delays corresponding to Table IV-1 are presented in Table IV-2 and correspond to the channel designations in Figure IV-7. Responses of the 0.75 cps low-cut filter (MCF 0) and the 1.0 through 2.0 cps bandpass filter (used in MCF 1 and 2) are shown in Figure IV-8.

Table IV-3 summarizes the fixed program now being employed in the processors.

D. RESEARCH ACTIVITIES

This subsection presents examples of on-line processed data, discusses some significant observations obtained thus far and reviews Dallas- and station-based research which will be conducted in conjunction with the operation and evaluation of the processor units.

1. On-Line Operation

The MCF and auxiliary processors have been operating on-line at CPO since 30 December 1966. On 4 and 5 January 1967, changes in the operating parameters were made in order to optimize computation of output data. Analysis of output data and evaluation of the auxiliary processor began on 6 January 1967. Figures IV-9 and IV-10 are examples of data which have been processed by the MCF and auxiliary systems during known signal conditions. These data have been reproduced from Develocorder film data routinely recorded on line at the observatory.

Table IV-1

PRESENT PROCESSOR OPERATING MODE

Title	Description
BS0*	Straight sum (Z1 - Z19)
BS1	North, velocity = 12.6 km/sec (Z1 - Z19)
BS2	East, velocity = 12.6 km/sec (Z1 - Z19)
BS3	South, velocity = 12.6 km/sec (Z1 - Z19)
BS4	West, velocity = 12.6 km/sec (Z1 - Z19)
BS5**	In-line summation toward Russia using Z4, 6, 7, 9, 14, 15, 17 and 19
BS6**	Transverse summation toward Russia perpendicular to BS5
BS7**	In-line summation approximately toward NTS using Z1, 2, 8, 10, 11, 12, 13, and 18
BS8**	Transverse summation approximately toward NTS perpendicular to BS7
MCF0	0.75 cps low-cut filter*
MCF1	MCF3[6] convolved with 1.0- to 2.0-cps bandpass filter
MCF2	IP10WGS[6] convolved with 1.0- to 2.0-cps bandpass filter
MCF3	MCF3[6]
MCF4	MCF24[6]

* MCF0 subsection prefilters the 19-channel data and presents it for use in the BS subsection

** Used as inputs to UK0 and UK1 of auxiliary processor

Table IV-2

CPO BEAM-STEER DELAYS*

Channel	BS0	BS1	BS2	BS3	BS4	BS5	BS6	BS7	BS8
Z 1	6	7	9	5	3	-	6	3	-
Z 2	6	6	7	6	5	-	6	5	-
Z 3	6	8	5	4	7	-	-	-	-
Z 4	6	8	4	4	8	9	-	-	7
Z 5	6	7	5	5	7	-	-	-	-
Z 6	6	5	5	7	7	5	-	-	7
Z 7	6	3	5	9	7	3	-	-	7
Z 8	6	5	6	7	6	-	5	7	-
Z 9	6	6	8	6	4	5	-	-	5
Z10	6	6	6	6	6	-	6	6	-
Z11	6	6	6	6	6	-	6	6	-
Z12	6	6	6	6	6	-	6	6	-
Z13	6	6	6	6	6	-	6	6	-
Z14	6	7	7	5	5	7	-	-	5
Z15	6	6	5	6	8	7	-	-	7
Z16	6	4	7	8	5	-	-	-	-
Z17	6	9	7	3	5	9	-	-	5
Z18	6	5	3	7	9	-	6	9	-
Z19	6	4	8	8	4	3	-	-	5

*All beam steers have a 6-sample delay added to each channel. All delays are in terms of processor time frames, $\Delta t = 0.05$ sec/frame.

Table IV-3

PROCESSOR PROGRAM DATA

MCF PROCESSOR

Channels	19
Filter points	57
Multichannel filters	5
Beam steers	9
Signal conditioner	All zeros
D-A converter	Channels 0 to 4 = -3 Channels 11 to 14 = -3
Beam-steer history	15
Time delay	28

AUXILLIARY PROCESSOR

Arithmetic drawer	UK0	56
	UK1	78
	UK History	40
	Fisher N1	777_8
	Fisher N2	20_8
	Fisher History	40
	MCF Power	R = 40, S = 1
Output drawer	UK0	-3
	UK1	-3
	MCF 0	-4
	MCF 1	-4
	MCF 2	-3
	MCF 3	-3
	Fisher	-15
Data truncation switches	Fisher	-3
	UK	-2
	MCF Power	-2
Fisher summation truncation switch		-7

UK0 and UK1 are absolute magnitude. Threshold switches are varied on a daily basis.

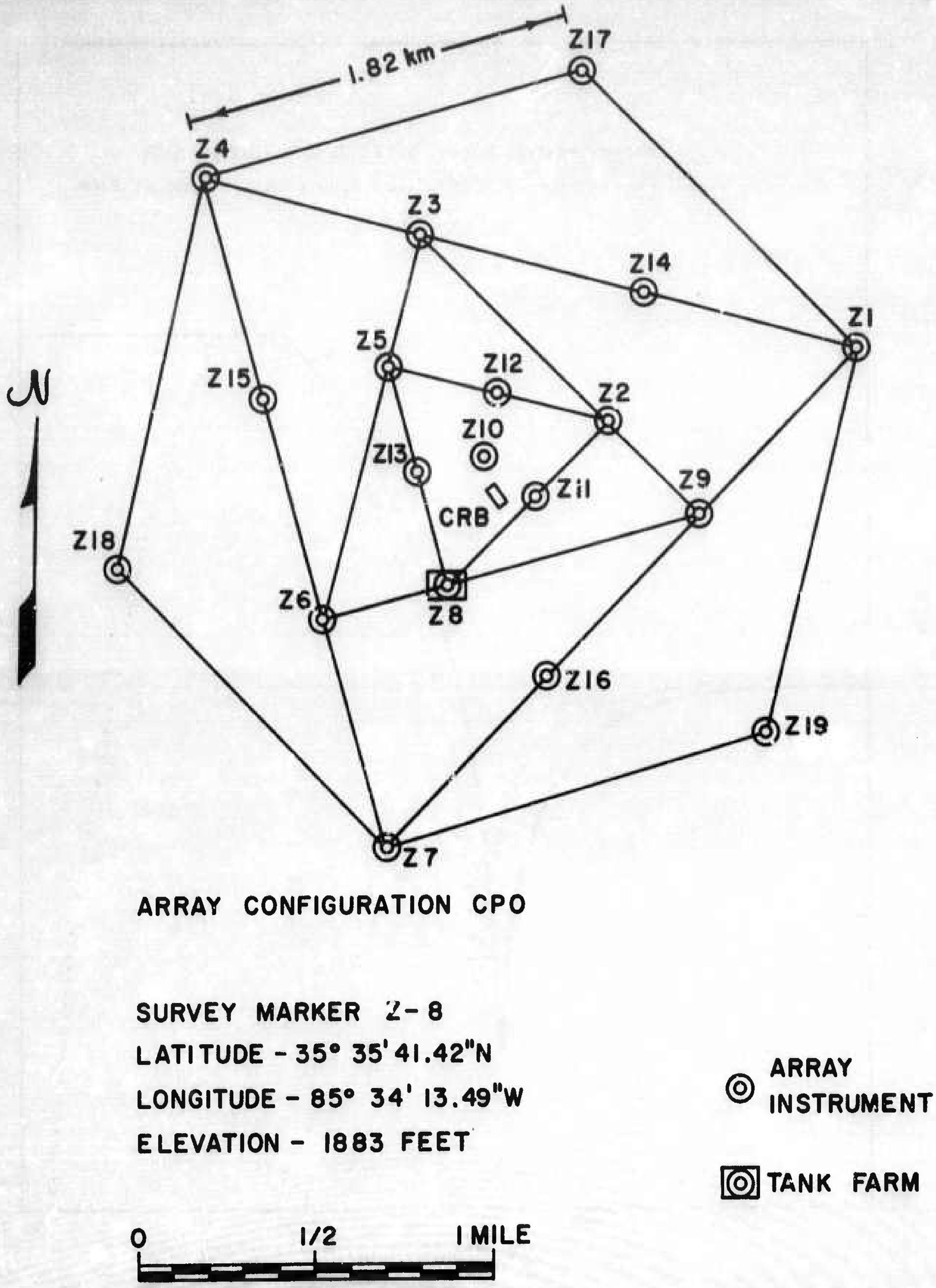


Figure IV-7. CPO Array

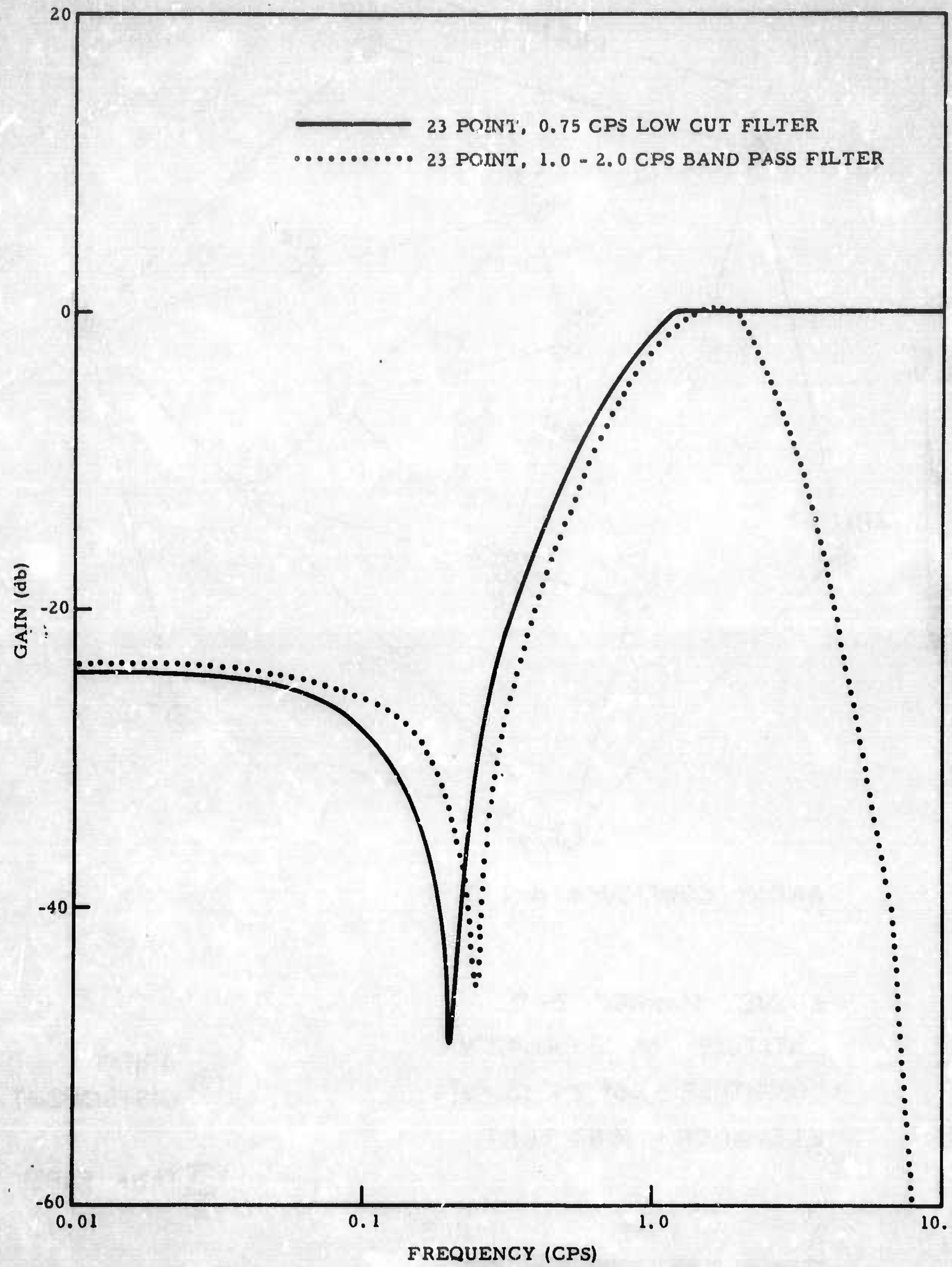
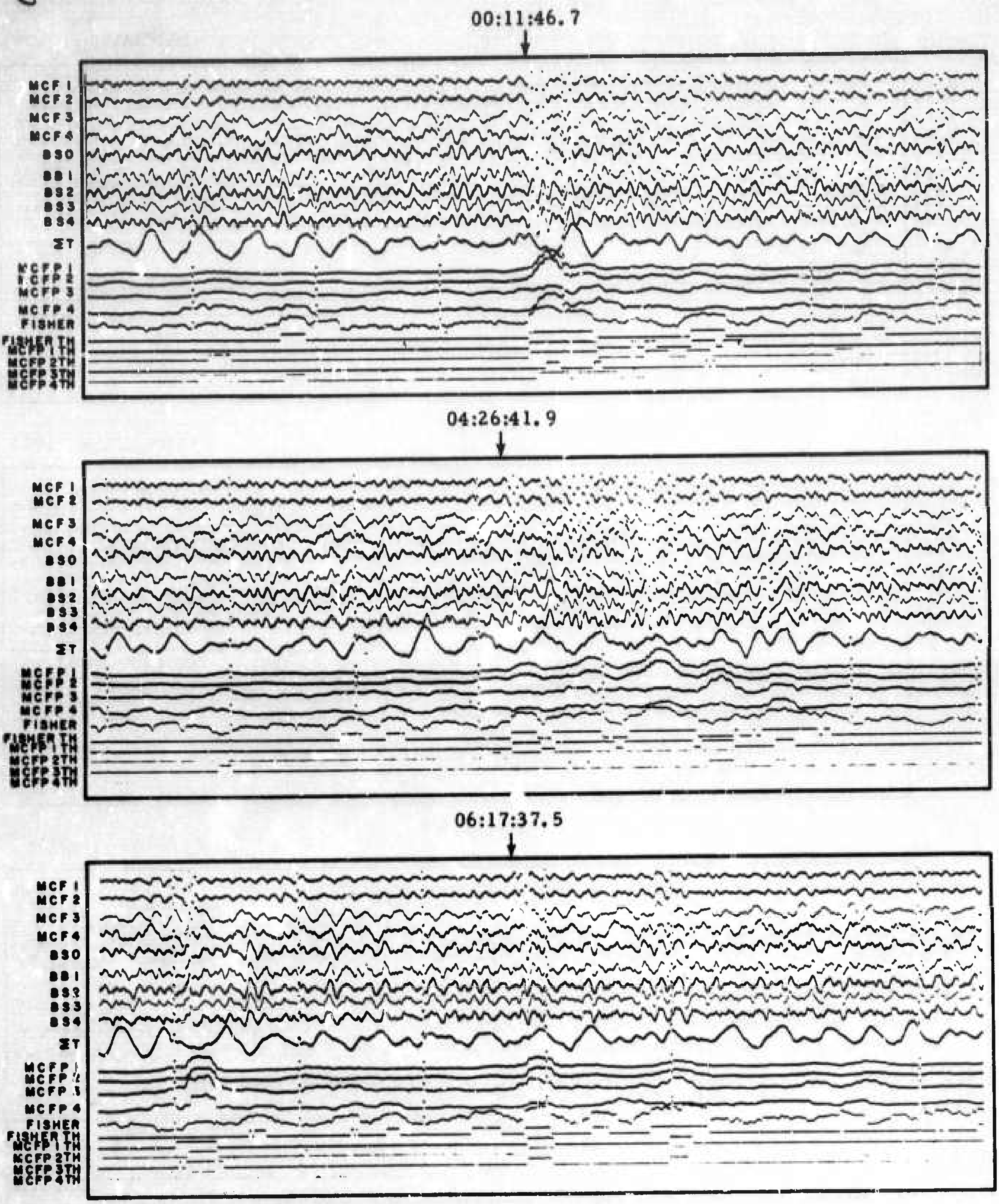


Figure IV-8. Responses of the 0.75 cps Low-Cut Filter and the 1.0 through 2.0 cps Bandpass Filter



JANUARY 6, 1967

Figure IV-9. Data Processed by the MCF and Auxiliary Systems During Known Signal Conditions

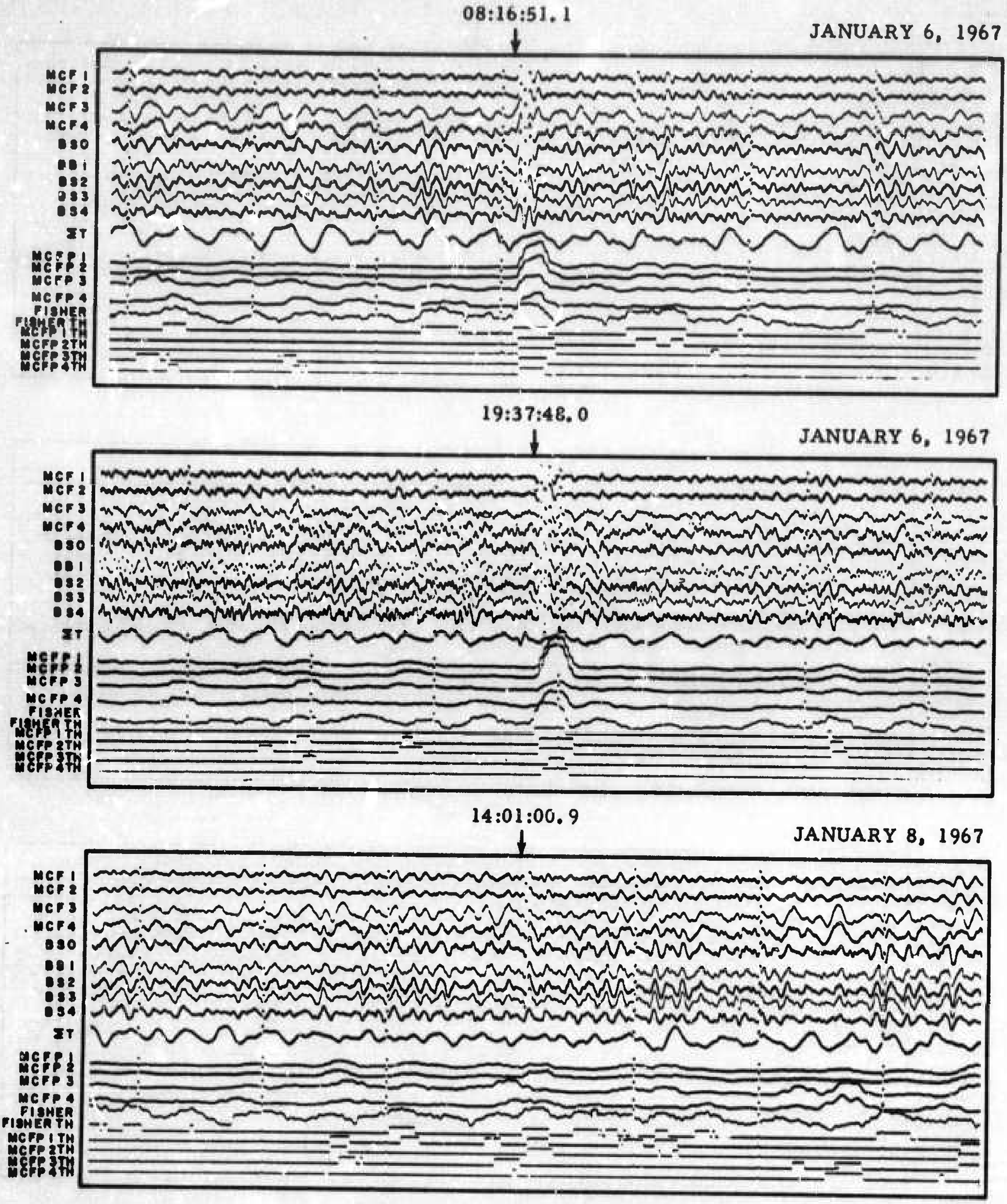


Figure IV-10. Data Processed by the MCF and Auxiliary Systems During Known Signal Conditions

2. Preliminary Observations

Several preliminary comments concerning effective use of the unit on-line can be made as a result of approximately one month's analysis of auxiliary processor data.

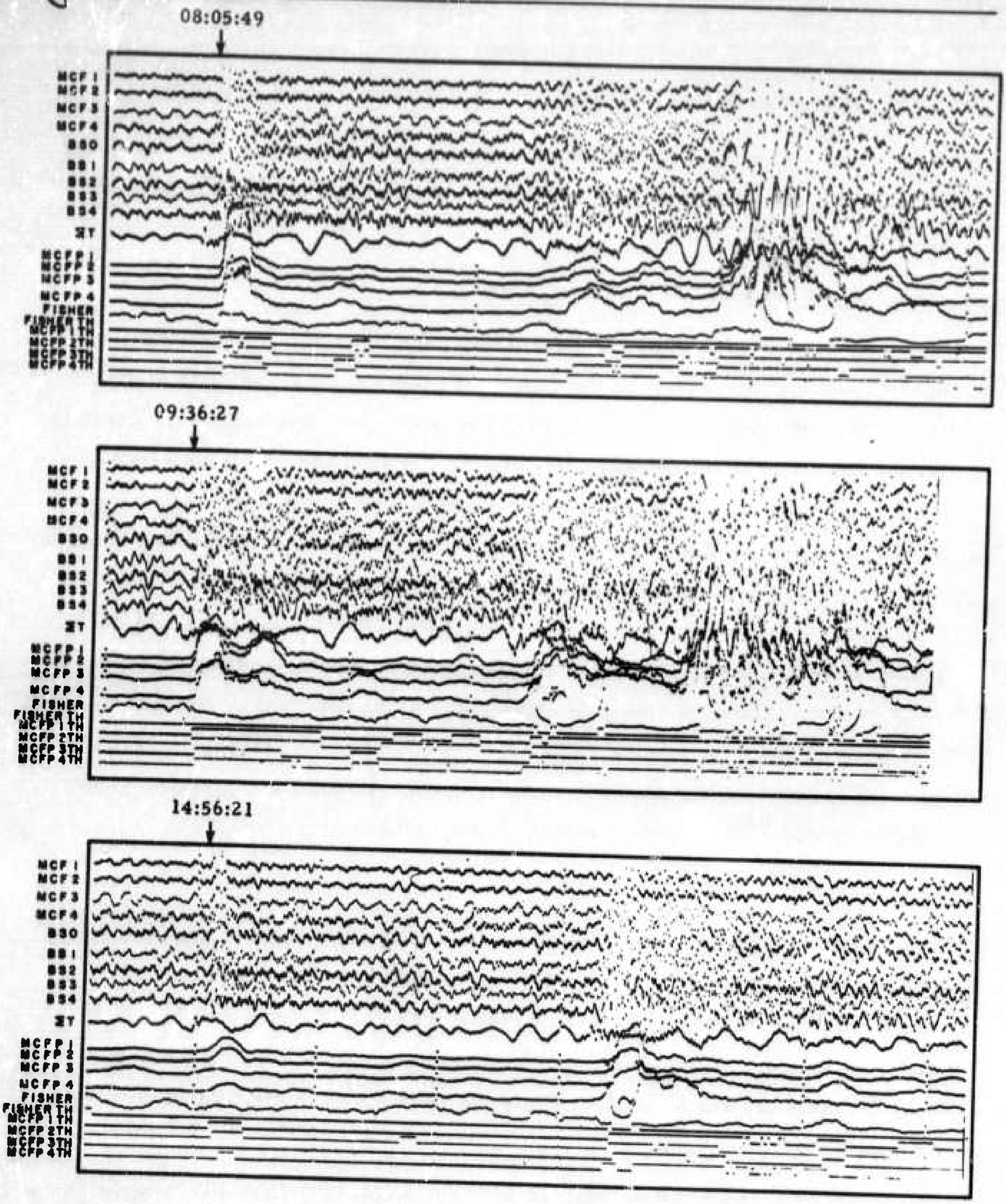
a. Fisher Vs MCF for Detection

Visual comparison of Fisher and Wiener power processing for detection purposes results in the conclusion that, for high velocity signals, the ratio of the peak signal output to the rms statistic computed over noise is larger for the MCF processes (Figures IV-9 and IV-10). This results holds true even in the case of Wiener power 3 and 4, which are wideband processes. Such a result migh be expected since the F-statistic assumes spatially random noise, which is not a valid assumption at CPO in the 0.1 to 2.0 cps band. Note that the Fisher statistic has been prefiltered with a 0.75 cps, 24 db/octave low-cut frequency filter. Some additional improvement in Fisher peak signal statistic to rms noise statistic may be obtained by low-cut filtering at higher corner frequencies (e.g., 1.0, 1.25, or 1.50 cps) since a greater percent of low velocity spatially organized energy would be rejected. This subject is covered in more detail in subsection D3.

b. Fisher Signal Response

Three quarry blasts processed by the auxiliary and MCF units are shown in Figure IV-11. A striking conclusion is noted when comparing the Fisher and Wiener detection traces: the Fisher is unaffected by the P- and S-wave energy falling in the velocity ranges 6.1 to 8.1 km/sec and 3.25 to 3.51 km/sec, respectively. (Note the reaction of the threshold detection traces.)

The MCF traces, as would be expected, pass the P-wave energy with little attenuation and reject some of the S-wave energy.



JANUARY 6, 1967

Figure IV-11. Three Quarry Blasts Processed by the MCF and Auxiliary Systems

As a result of this velocity response function, the Fisher process is an invaluable aid in observatory analysis to rapidly detect low velocity P- and S-wave energy. (Low velocity P- and S-wave energy indicates a regional, near regional or local event.)

The development of a $\vec{k}$-space response model for the Fisher process which is needed to more fully understand the Fisher signal response, is discussed in greater detail under the research tasks.

c. Threshold Detectors

Optimum on-line employment of the threshold detectors has been hampered by the apparent nontime-stationarity of the critical values. The optimum critical value (threshold level), defined as that level yielding a predetermined false alarm rate percentage, is highly dependent upon the ambient noise level, which varies with cultural and weather conditions.

Experience in operating the auxiliary processor has thus far shown that the critical value for both Wiener and Fisher processes must be determined and updated at least daily and possibly more often for these outputs to be of value. Present techniques for determining the daily threshold setting are at best crude and have room left for improvement.

Additional emphasis will be placed on finding appropriate manual threshold determination techniques. The most obvious solution to the nontime-stationarity problem would be using a self-adapting threshold which could be implemented into the hardware with minimal change.

3. Planned Research Activites

The evaluation of the auxiliary processor as a detection tool is of primary importance to the contract goals. Comprehensive evaluation will be accomplished through a program of observatory analysis and statistical data collection, coupled with appropriate supporting basic research in the use and interpretation of Fisher and Wiener power detection processing.

a. Observatory Conducted Research

Statistics will be collected to give tangible evidence of the improvement gained using the auxiliary processor as a detection device on-line at CPO. Fundamentally, the statistics will define the percent increase in detection capability as determined by visual analysis of film data.

Daily routine analysis is being conducted concurrently over two independent sets of array data. The first set consists of data available prior to installation of the MCF and auxiliary processor (i.e., primary, secondary, and LP data), and the second set consists of MCF and auxiliary processor data.

Two listings of events, one from each data set, are being compiled. The analysis routine is unchanged. Results of the MCF- auxiliary processor analysis are recorded on the form shown in Table IV-4. (Note that on the last list, only primary P-wave arrivals will be recorded.)

Processing P-wave arrival data of each list should include:

- Correlation of events on each list to known reported events
- Computation of percent of events detected on each list and percent of events missed
- Computation of percent increase afforded by the processor data
- Comparison of events detected vs events identified by the threshold detector
- Comparison of Fisher vs MCF detection capability

Table IV-4

CPO MCF DAILY EVALUATION LOG

Page No.___ of ___

Date__________ WT1__________ WT3________ FT________

Gate Length__________ WT2__________ WT4________

P. Arrival Time	DETECTABLE ON					DETECTABLE ON				
	W1	W2	W3	W4	F	FT	WT1	WT2	WT3	WT4

As the effort progresses, consideration will be given to adopting other evaluation techniques and/or to computing additional statistics. Also, the January data may be reanalyzed, since there will have been some loss of accuracy and continuity due to the analysts' "learning curve."

As previously pointed out, the present nontime-stationarity difficulties being experienced with the threshold detector levels are causing considerable inaccuracy in the evaluation of "automatic" detection (i.e., analysis of data on the basis of the threshold detectors and subsequent determination of additional improvement gained by employing this type of detector).

b. Supporting Detection Processing Research

The primary goals of this effort are: first, find the optimum operating configuration for each of the detection processes, and second, support the data collected under the on-line evaluation with controlled statistics and conclusions developed off-line. These statistics and conclusions should enhance the quality and accuracy of the evaluation and add basic understanding to the final results.

Data developed under this effort will:

- Determine the optimum computation gate lengths for the Fisher and Wiener power statistics based upon signal considerations
- Determine the optimum frequency filter to be applied to data input to the Fisher process
- Compute the Fisher velocity response to coherent plane wave energy
- Compute the interdependence between the critical value and the false alarm rate for a fixed gate and for a prefilter of an average ambient noise ensemble
- Determine the interdependence between the non-time-stationary rms noise power and the critical value for other fixed parameters

Work on the first two items is underway.

Frequency filters have been developed with corner frequencies of 0.50, 0.75, 1.0, 1.25, 1.50, and 1.75 cps. Each filter is low-cut with a 24 db/octave slope. These will be successively applied on-line, and the effect on the Fisher output noise statistic will be measured to determine the optimum pass band.

The optimum gate length for computation purposes is being estimated by determining the average low-level P-wave pulse length visually detected at CPO on confirmed events. Once determined, the optimum gate will be assumed to be this average pulse length.

SECTION V

REFERENCES

1. Texas Instruments Incorporated, 1966: CPO Quarterly Rpt. No. 4, Contract AF 33(657)-14648, 28 Oct.

2. Texas Instruments Incorporated, 1965: CPSO Quarterly Rpt. No. 1, Contract AF 33(657)-14648, 8 Aug.

3. Texas Instruments Incorporated, 1966: CPO Quarterly Rpt. No. 3, Contract AF 33(657)-14648, 29 Mar.

4. Texas Instruments Incorporated, 1966: CPO Quarterly Rpt. No. 5, Contract AF 33(657)-14648, 9 Nov.

5. Seismic Data Laboratory, 1965: Analysis of Variance as a Method of Seismic Signal Detection, Contract AF 33(657)-12447, 25 Feb.

6. Texas Instruments Incorporated, 1966: CPO Annual Rpt. No. 1, Appendix A, Contract AF 33(657)-14648, 15 Sept.

APPENDIX A

CPO MULTICHANNEL FILTER LOGIC POWER SUPPLY MONITOR

APPENDIX A

CPO MULTICHANNEL FILTER LOGIC POWER SUPPLY MONITOR

A. GENERAL

A circuit designed to Texas Instruments specifications by Dressen Barnes was added to the +4 v, 50 amp Dressen Barnes logic power supply of the CPO multichannel filter. This circuit allows the processor to survive transients found to cause memory core losses. These transients were short, power-line transients which were too brief to trip the Fabritek memory, resulting in a loss of data. The circuit was added to the logic supply and monitors the unregulated voltage decreases to a value that would endanger regulation of the +4-v output.

B. RESULTS

Figure A-1 is the schematic of the circuit added to the logic power supply. The circuit consists primarily of a time delay circuit and a Schmitt trigger. The time delay circuit insures that, during power turn on, the processor will remain in the stop mode until an unregulated +30-v signal reaches a magnitude necessary to maintain the proper bias for the Schmitt trigger. The Schmitt trigger is used to monitor the unregulated +14 v feeding the series regulators.

The monitor circuit was installed and tested. Using the following format, approximately 50 power transients were imposed on the system during normal operation.

MCF		Auxiliary Processor	
Inputs	32	UK History Length	24
Filter Points	25	MCF Power Intervals	6
Outputs (MCF)	4	MCF Power Samples	6
Outputs (B.S.)	10	Fisher History Length	7
B.S. History Length	30	Fisher N1 Normalization Constant	700
		Fisher N2 Normalization Constant	300

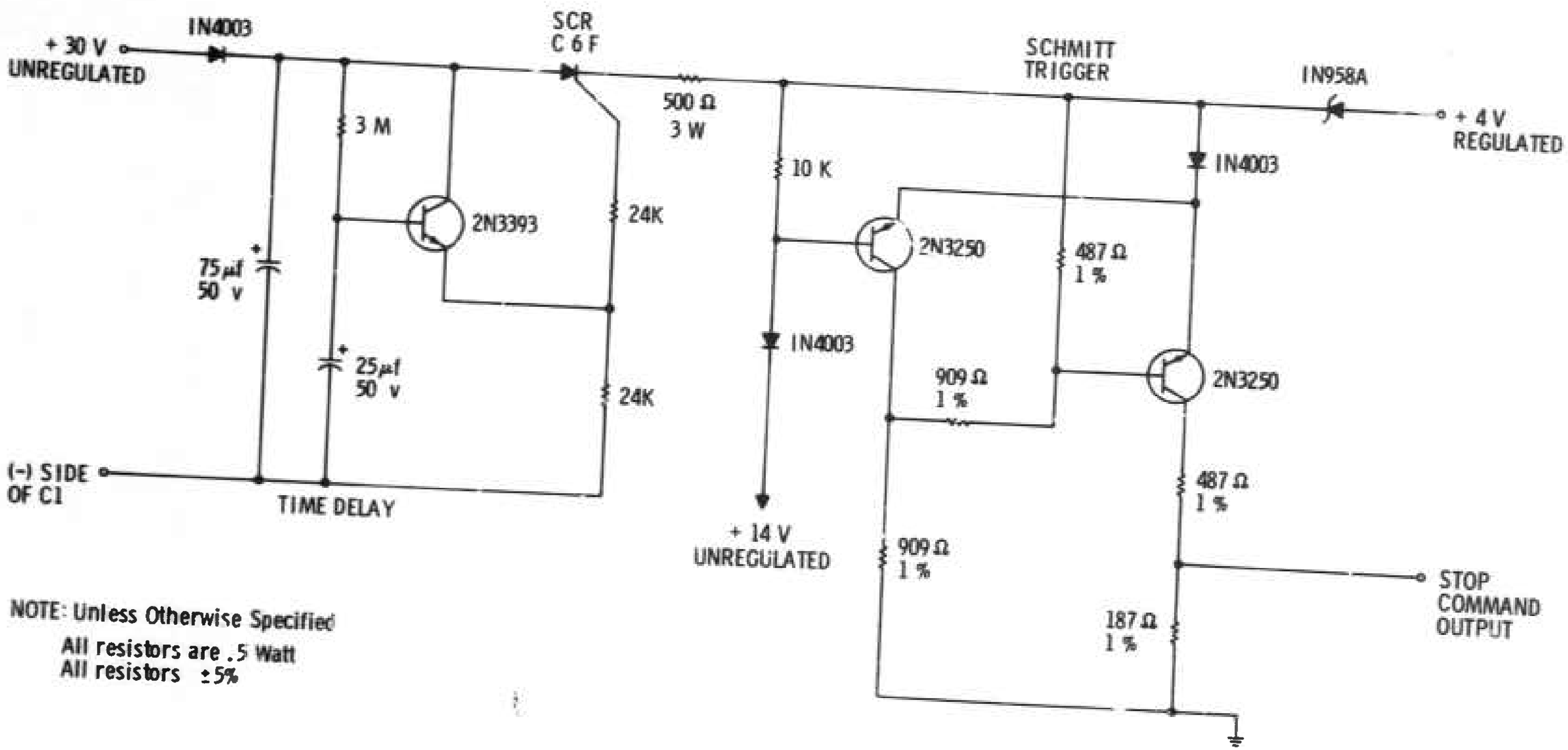
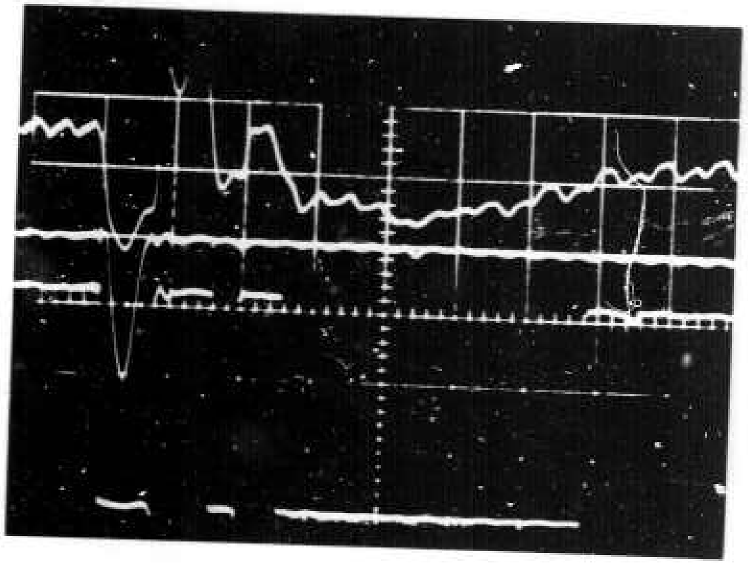


Figure A-1. Dressen Barnes Logic Power Supply Monitor

By means of the off-line, all-channel step test, approximately 4700 memory locations were checked, and no loss of memory resulted from any of the power transients.

Action of the circuit is shown in Figure A-2. The upper trace is the unregulated +14-v signal to the series regulator, which is the signal that the Schmitt trigger monitors. The second trace is the regulated +4-v stop command signal, which is the output of the monitor circuit. The processor goes to the stop mode within 10 μsec of receipt of a 0-v command signal.

As shown in Figure A-2, a power transient causes a depreciable change in the +14-v unregulated signal. The +4-v regulated signal is lost when the +14-v signal decreases to approximately 7 v. However, the stop command signal goes to zero when the +14-v signal decreases to approximately 10 v. The processor is thus set to the stop mode before the power line transient effects can endanger the memory contents.



F e A-2. Operation of the Power Supply Monitor Circuit to Severe Transients

APPENDIX B

CPO EVENTS WITH AND WITHOUT MCF

Table B-1

WITHOUT MCF

660901	6609041000262	6609082208122	6609130321057
6609010147575	6609041057342	6609082340350	6609130555455
6609010803069	6609041128246	6609082131104	6609131425037
6609010916163	6609041311069	6609080015358	6609132202589
6609010947420	6609041330206	660909	6609132204430
6609011247462	6609042051150	6609090109130	6609132238159
6609011418143	6609042105186	6609090412045	6609131042530
6609011419144	6609042221256	6609090537116	6609131803492
6609011435078	660905	6609090632386	660915
6609011444531	6609050314447	6609090953100	6609150127287
6609011640463	6609050440230	6609091201007	6609150243184
6609011927255	6609050711372	6609091224143	6609150313317
6609012327356	6609050859104	6609091351400	6609150355017
6609012117254	6609051054332	6609091519537	6609150408094
6609011117040	6609051145523	6609091832460	6609150456433
6609010716180	6609051417100	6609091840414	6609150626235
6609010612157	6609051643487	6609091845536	6609150640305
6609010331198	6609051817510	6609091852500	6609150810108
6609010251016	6609052341127	6609092108265	6609150811081
660902	6609052245552	6609092324204	6609150813276
6609020210570	6609051643485	6609092359128	6609150932417
6609020303291	6609051614534	6609091540470	6609151042440
6609020411263	6609050841526	660910	6609151210250
6609020508066	6609050419119	6609100001320	6609151218353
6609020636566	660906	6609100239555	6609151729259
6609020705464	6609060014480	6609100417547	6609151739583
6609020807137	6609060102464	6609100614512	6609151800040
6609021441124	6609060203093	6609100702556	6609152136010
6609021453589	6609060443322	6609101345463	6609152355086
6609021717313	6609060702551	6609101415564	6609150202230
6609022125216	6609060717200	6609101423457	6609151137360
6609022223080	6609060755374	6609101526515	6609151743322
6609022224497	6609061136161	6609101544232	6609151927106
6609022256353	6609061730053	6609101620420	660916
6609020637250	6609061755364	6609101638410	6609160257515
6609022132531	6609062036118	6609101817437	6609160809453
660903	6609062112054	6609102150524	6609161234362
6609030206443	6609062208184	6609102203562	6609161457405
6609030221417	6609060646293	6609100534170	6609161720077
6609030515541	6609060807523	6609102016400	6609162345186
6609030643012	6609060852397	660912	6609162206224
6609030824243	6609061627325	6609120201243	660917
6609031226483	6609061939343	6609121148153	6609170131554
6609031630305	660908	6609121535224	6609170547408
6609032249334	6609080024505	6609121607357	6609170551409
6609030804450	6609080409054	6609121646511	6609170556531
6609031155090	6609080534135	6609121726110	6609171102473
660904	6609080539237	6609121824460	6609171303006
6609040040501	6609080603524	6609122340233	6609171543047
6609040135043	6609080648000	6609122354163	6609171729434
6609040456173	6609080838477	6609122340232	6609172329326
6609040459400	6609080937211	6609120806145	6609172336240
6609040504555	6609081220540	6609120132217	6609170035470
6609040547170	6609081335154	660913	6609171126060
6609040548113	6609082036295	6609130118055	660918
6609040945146	6609082134440	6609130124358	6609180228371

6609180310440
6609180333425
6609180535273
6609180651452
6609180752308
6609180812540
6609181002486
6609181056050
6609181413113
6609181532560
6609181707534
6609182058119
6609182148512
6609182213554
6609182215428
660919
6609190145541
6609190436154
6609190515425
6609190625337
6609190731245
6609190945069
6609191011375
6609191701064
6609192337541
6609191108408
660920
6609200017390
6609200049300
6609200358266
6609200550254
6609200624531
6609200942364
6609201135011
6609201441449
6609201839466
6609202349246
6609200143272
6609202045144
660921
6609210036132
6609210416190
6609210743508
6609210837088
6609210937245
6609211628039
6609211927070
660922
6609220016070
6609220024215
6609220133315
6609220428545
66092205315[illegible]1
6609220616300
6609220626009
6609221040185
6609221140520
6609221828267
6609221901440
6609221902376
6609222022276
6609222337153
6609221806290
6609220359233
6609221021343
6609221320249
6609221836204
6609221935376
6609222004441
6609222011497
6609222041052
660923
6609230051425
6609230142219
6609230218390
6609230528060
6609230733475
6609231201185
6609231726200
6609231844071
6609231855344
6609231906543
6609232200541
6609230327209
6609230644324
660925
6609250044239
6609250255319
6609250507500
6609250607017
6609250623414
6609250641450
6609250717324
6609251014232
6609251054436
6609251226228
6609251419475
6609252031209
6609251043433
660926
6609260529411
6609260540086
6609260937520
6609261455394
660927
6609270358345
6609270640343
6609270643424
6609270801078
6609271107144
6609271142146
6609271421460
6609271516309
6609271533215
6609271900445
660928
6609280015120
6609280243170
6609280839277
6609281419057
6609282037164
6609282041102
6609282345323
6609281627034
660929
6609290001162
6609290058263
6609290211082
6609290447552
6609290448262
6609290649479
6609291054462
6609291514339
6609291634182
6609291654046
6609292313005
6609292345140
660930
6609300019391
6609300046548
6609300051183
6609300250406
6609300335346
6609300423543
6609300610442
6609300708094
6609300842441
6609300911026
6609300916565
6609300938354
6609301038015

Table B-2
WITH MCF

660901
6609010147568
6609010251011
6609010331196
6609010612260
6609010716180
6609010811088
6609010816124
6609010828516
6609010916156
6609010942140
6609011117040
6609011123329
6609011247461
6609011418143
6609011429522
6609011435132
6609011444530
6609011640462
6609011723552
6609011749528
6609011927253
6609012117255
6609012138513
6609012327350
660902
6609020041539
6609020105330
6609020154093
6609020210499
6609020303340
6609020314516
6609020429342
6609020508063
6609020636575
6609020637250
6609020659297
6609020705462
6609020727204
6609020807136
6609020857440
6609021030539
6609021441123
6609021453591
6609021504158
6609021717309
6609022125214
6609022132531
6609022223065
6609022224497
6609022256352
660903
6609030206438
6609030221417
6609030403462
6609030419227
6609030643010
6609030804442
6609030824241
6609030951099
6609031155081
6609031226480
6609031630304
6609031730222
6609032249334
6609032309360
6609032328458
660904
6609040040510
6609040102539
6609040117319
6609040135036
6609040456175
6609040458390
6609040459400
6609040504554
6609040547169
6609040945143
6609041000257
6609041[illegible]7336
6609041128239
6609041311067
6609041750094
6609041906430
6609041938137
6609042053351
6609042105186
6609042108205
6609042215487
6609042221245
660905
6609050019311
6609050030510
6609050035203
6609050037590
6609050040403
6609050157305
6609050249026
6609050314451
6609050419119
6609050620205
6609050649162
6609050709040
6609050711373
6609050841526
6609050859100
6609051128518
6609051203267
6609051323420
6609051417184
6609051423367
6609051442347
6609051614534
6609051643485
6609051654198
6609051747413
6609051817478
6609051843036
6609052045552
6609052221127
6609052246244
6609052310512
6609052322538
6609052348376
660906
6609060014481
6609060102461
6609060106118
6609060148359
6609060202532
6609060234529
6609060320598
6609060321565
6609060326314
6609060356422
6609060443316
6609060500555
6609060646293
6609060656310
6609060704205
6609060717210
6609060748101
6609060807523
6609060852397
6609060900350
6609060[illegible]7317
6609061136172
6609061244142
6609061250571
6609061627325
6609061755357
6609061939343
6609062036117
6609062112050
6609062208183
660907
6609070104264
6609070405164
6609070423578
6609070533049
6609070824331
6609070932228
6609071007116
6609071028594
6609071059222
6609071215087
6609071451507
6609071502343
6609071613480
6609071632222
6609071656115
6609071803511
6609072034045
6609072041178
6609072306019
660908
6609080015358
6609080024507
6609080409054
6609080534137
6609080539237
6609080603521
6609080647599
6609080831101
6609080838478
6609080846185
6609080937211
6609081101546
6609081209471
6609081220538
6609081233564
6609081335154
6609081703136
6609081749195
6609082036352
6609082131104
6609082134513
6609082208122
6609082340350
660909
6609090041230
6609090109129
6609090214454
6609090306013
6609090412045
6609090537117
6609090801420
6609090953195
6609091200597
6609091224117
6609091233582
6609091351398
6609091519537
6609091540464
6609091832456
6609091840405
6609091845551
6609091852501
6609092108263
6609092211038
6609092324206
6609092359132
660910
6609100037311

Table B-2 (Contd)

6609100123050	6609112150534	660915	6609170105061
6609100131062	6609112321489	6609150026587	6609170123094
6609100239554	6609112348420	6609150127445	6609170131546
6609100302542	660912	6609150202232	6609170441352
6609100417544	6609120000548	6609150231057	6609170444515
6609100534178	6609120101406	6609150239430	6609170551005
6609100614511	6609120132217	6609150243132	6609170556536
6609100649116	6609120201241	6609150252028	6609170946132
6609100702556	6609120216306	6609150313345	6609170949303
6609100937558	6609120806145	6609150355017	6609171004417
6609101005251	6609121039153	6609150408086	6609171102465
6609101047247	6609121109129	6609150437408	6609171126060
6609101107366	6609121144574	6609150456435	6609171303003
6609101155236	6609121218494	6609150541156	6609171729434
6609101345461	6609121219497	6609150545103	6609171805436
6609101415480	6609121311028	6609150626217	6609172329328
6609101423457	6609121526195	6609150641060	6609172336216
6609101434247	6609121535220	6609150810108	660918
6609101526521	6609121607357	6609150813272	6609180228472
6609101605172	6609121618051	6609150825276	6609180333422
6609101620418	6609121644538	6609150932417	6609180535265
6609101638410	6609121646510	6609151041341	6609180651452
6609101653259	6609121726036	6609151042396	6609181002479
6609101749506	6609121745179	6609151137358	6609181056048
6609101817441	6609121824458	6609151206090	6609181142226
6609102001467	6609121836498	6609151218352	6609181413112
6609102016400	6609122113460	6609151234164	6609181532562
6609102116557	6609122340232	6609151729252	6609181707532
6609102150524	660913	6609151739583	6609181738390
6609102203454	6609130052573	6609151743440	6609181911334
6609102223242	6609130118055	6609151753568	6609182038425
660911	6609130321055	6609151800036	6609182055307
6609110007413	6609130555456	6609151927106	6609182058112
6609110023551	6609130650420	6609152136011	6609182148508
6609110147130	6609131031016	6609152247551	6609182213561
6609110218250	6609131042530	6609152355082	6609182215477
6609110256333	6609131425033	660916	660919
6609110326572	6609131803492	6609160031167	6609190055350
6609110408004	6609131814075	6609160110142	6609190145539
6609110418328	6609132202589	6609160208592	6609190354283
6609110542578	6609132238145	6609160257515	6609190436154
6609110722057	6609132344045	6609160512457	6609190451276
6609110731590	660914	6609160520469	6609190454470
6609110742042	6609140004123	6609160652518	6609190515417
6609111030361	6609140007398	6609160707563	6609190625337
6609111033246	6609140116008	6609160737597	6609190725544
6609111045119	6609140304278	6609160756450	6609190731242
6609111125418	6609140340246	6609160809502	6609190827571
6609111254264	6609140403137	6609160914351	6609190945059
6609111353472	6609140419069	6609161234364	6609191011366
6609111354414	6609140614448	6609161457402	6609191108408
6609111406129	6609140937276	6609161720078	6609191701060
6609111628377	6609140959178	6609162206224	6609192028581
6609111744082	6609141118528	660917	6609192215113
6609111818427	6609141944275	6609170035476	6609192337541
6609111925590	6609142332549	6609170047172	660920

6609200016571
6609200049298
6609200143272
6609200233064
6609200331521
6609200358266
6609200410522
6609200550254
6609200624532
6609200833078
6609200942318
6609201222287
6609201412469
6609201415201
6609201441441
6609201839466
6609202045144
6609202349246
6609202355281
660921
6609210029349
6609210036128
6609210037328
6609210220534
6609210238480
6609210259488
6609210416171
6609210418042
6609210456446
6609210559168
6609210610123
6609210710359
6609210743505
6609210842565
6609210937275
6609211119146
6609211453002
6609211628036
6609211927064
660922
6609220016068
6609220024209
6609220106158
6609220130427
6609220133316
6609220359233
6609220416534
6609220428569
6609220531519
6609220616295
6609220705079
6609220819074
6609221031343
6609221320249
6609221613235
6609221806283
6609221828261
6609221836204
6609221901440
6609221902376
6609221935376
6609221948342
6609222004441
6609222011497
6609222022291
6609222141052
6609222312450
660923
6609230051420
6609230142217
6609230218388
6609230250441
6609230327209
6609230607557
6609230618499
6609230644324
6609230733473
6609230958047
6609231201170
6609231346109
6609231428282
6609231439576
6609231836024
6609231844063
6609231855340
6609231906539
6609232200541
660924
6609240000075
6609240025547
6609240028247
6609240126549
6609240546472
6609240737288
6609240805403
6609240832443
6609240905399
6609241104520
6609241249392
6609241627360
6609242033246
6609242111078
6609242359208
660925
6609250044236
6609250156298
6609250255315
6609250507485
6609250607016
6609250623415
6609250717318
6609250852543
6609250950152
6609251014230
6609251043433
6609251054436
6609251111049
6609251226216
6609251419474
6609251851490
6609251919033
6609252031209
6609252142457
660926
6609260002068
6609260238161
6609260354389
6609260529411
6609260537122
6609260540074
6609260745409
6609260846044
6609260937496
6609261233183
6609261455394
6609262152525
660927
6609270358345
6609270438374
6609270622159
6609270640343
6609270643418
6609270748041
6609270801072
6609270943024
6609271106022
6609271107142
6609271142139
6609271421461
6609271516306
6609271533214
6609271741155
6609271845113
6609271900437
660928
6609280015117
6609280101028
6609280243170
6609280438452
6609280614585
6609280712547
6609280839270
6609281046243
6609281409001
6609281415295
6609281624322
6609281627034
6609282037134
6609282041103
6609282345319
660929
6609290001110
6609290058260
6609290130594
6609290447547
6609290448260
6609290649471
6609290728534
6609290758463
6609290930129
6609290933541
6609291016549
6609291049335
6609291244231
6609291250523
6609291325548
6609291514338
6609291547015
6609291634175
6609291654039
6609292313005
6609292345137
660930
6609300019425
6609300046547
6609300051179
6609300423541
6609300610441
6609300708086
6609300910584
6609300916537
6609300938353
6609301038011
6609301412455
6609301808190
6609302308545